1. INTRODUCTION

The U.S. Department of Energy (DOE) is evaluating its options for two separate but related sets of decisions pertinent to the management of the spent nuclear fuel (SNF) for which the DOE is responsible. As a result, this Environmental Impact Statement (EIS) is divided into two parts. Volume 1 involves programmatic (DOE-wide) approaches to the management of DOE's SNF; Volume 2 discusses site-specific approaches for environmental restoration and waste management activities at the Idaho National Engineering Laboratory, including SNF management. This EIS has been prepared in accordance with the National Environmental Policy Act and its applicable implementing regulations (40 CFR Parts 1500-1508 and 10 CFR Part 1021).

The DOE's proposed action for Volume 1 is to safely, efficiently, and responsibly manage existing and projected quantities of DOE's SNF through the year 2035, pending ultimate disposition. Volume 1 has been developed to support DOE's decisionmaking on the most appropriate location for implementing national strategies for managing DOE's SNF until its ultimate disposition is determined and implemented. For planning purposes, it has been assumed that decisions regarding ultimate disposition strategies may require as long as 40 years to implement. The general environmental consequences of managing SNF in a range of configurations at various sites are summarized in this volume.

Volume 1 is supported by site-specific appendices (under separate cover) that provide detailed information on the consequences of management activities under each alternative at the Hanford Site (Appendix A); Idaho National Engineering Laboratory (Appendix B); Savannah River Site (Appendix C); naval SNF management facilities, including management of naval SNF at DOE facilities (Appendix D); other generator/storage sites (Appendix E); and the Oak Ridge Reservation and the Nevada Test Site (Appendix F). This EIS does not select site-specific technical management options presented in Appendices A through F. The management options are representative of potential activities at each of the sites under consideration.

Volume 2 addresses the Environmental Restoration and Waste Management Programs at the Idaho National Engineering Laboratory. DOE objectives for the next 10 years are to mitigate the impacts of past operations through environmental restoration and to treat, store, or dispose of waste at the Idaho National Engineering Laboratory in a way that minimizes future adverse impacts.

Volume 3 summarizes the comments that DOE received on the Draft EIS during the public comment period and provides responses to those comments. Volume 3 also discusses the extent to which public comments resulted in changes to this EIS and describes how to find specific comment summaries and responses.

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a. The Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement (SNF and INEL EIS)

1.1 Overview of Spent Nuclear Fuel in the DOE Complex

This section is an introduction to the nature, types, and quantities of DOE SNF; the historic generation and storage of SNF; and the current program structure as it existed in April 1995. This section also explains what SNF is not included in this EIS as DOE SNF.

1.1.1 What is Spent Nuclear Fuel

Nuclear reactors use a process called fission to generate heat to produce electricity and to generate power to propel Navy ships and submarines. Production reactors have been used to produce defense materials at DOE facilities and radioisotopes for industrial and medical use. Some colleges and universities, government facilities, and commercial establishments use nuclear reactors for research and educational purposes, as well. Fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated, is called spent nuclear fuel, or SNF. The EIS also evaluates uranium/neptunium target materials, blanket subassemblies, pieces of fuel, and debris. Contact-handled fuel/targets (that is, fuel/targets with radiation levels low enough to permit handling without shielding or remote operations), even though slightly irradiated, are not included. This material will be managed by DOE along with the other excess nuclear materials.

1.1.1.1 Configuration of Nuclear Fuel.

The fuel in a nuclear reactor consists of fuel assemblies that may range in number from one to several hundred, depending upon the reactor size and the design of the reactor and fuel assemblies. Fuel assemblies are constructed in many configurations, but they generally consist of the fuel matrix, cladding, and structural hardware.

The fuel matrix contains the fissionable material (typically uranium oxide or uranium metal). The matrix form is typically plates or cylindrical pellets. For gas-cooled reactors, the matrix may be small particles. The cladding is the encapsulation (typically zirconium, aluminum, or stainless steel) that surrounds the fuel, confining and protecting it. For gas-cooled reactors, this may be a ceramic coating over the fuel particles.

The structural parts of a fuel assembly hold fuel in the proper configuration and direct coolant flow (typically water) over the fuel. Structural hardware is generally nickel alloys, stainless steel, zirconium, or aluminum, or, for gas-cooled reactors, graphite. The size of a fuel assembly ranges from a weight of 1 kilogram (2.2 pounds) and a length of less than 1 meter (3 feet) to a weight of more than 450 kilograms (1,000 pounds) and a length of more than 3 meters (10 feet). Figure 1-1 illustrates a representative fuel element.

Figure 1-1. Representative reactor fuel assembly and element.

1.1.1.2 Properties of Spent Nuclear Fuel.

When it is initially removed from a reactor, SNF is highly radioactive. A fraction of the initial mass of fissionable material (uranium-235 or plutonium) has been converted into fission products, some of which are radioactive with half-lives ranging from a few seconds to thousands of years. At the time of withdrawal from the reactor, most of the radioactivity is associated with fission products with very short half-lives. The radioactivity from SNF decreases very rapidly over time after irradiation. After 1 year, the levels are about 1 percent of that at the time of removal. After 10 years, these levels have decreased by another factor of 10.

The radiation of most concern from SNF is gamma rays. Although the radiation levels can be very high, the gamma-ray intensities are readily reduced by shielding fuel elements with such materials as concrete, lead, steel, and water. The thickness of the required shielding is dependent on the energy of the radiation source, the desired protection level, and the density of the shielding material. Typically, shielding thicknesses for concrete or lead are much smaller than for water.

The radioactivity produces heat, and the assemblies must be cooled for a period of months to years following removal from the reactor to prevent excessive fuel temperatures from being reached. Typically, the SNF removed from reactors has been stored in water pools for a period of 3 to 18 months for cooling before transfer to other facilities for storage or processing. Storage systems are designed to prevent nuclear criticality (nuclear chain reaction).

Many fuel elements that are now SNF, particularly production reactor fuel, were designed to be easily dissolved in nitric acid for uranium-235 and plutonium recovery. Because the fuels were designed for only short-term storage, prolonged storage sometimes presents problems. For example, some fuels, such as aluminum-clad fuels, corrode during prolonged storage in water pools unless the water chemistry within the pool is carefully controlled. Corrosion can result in cladding failures and the release of small quantities of fission products, especially radioactive gases and readily soluble isotopes.

1.1.1.3 SNF Management Vulnerabilities.

Prolonged storage of some types of SNF has resulted in deterioration of the cladding, degradation of the fuel matrix, or other storage problems leading to significant environmental, safety, and health concerns. DOE reported its evaluation of these concerns in a Spent Fuel Working Group Report on Inventory and Storage of the Department's Spent Nuclear Fuel and Other Reactor Irradiated Nuclear Materials and their Environmental, Safety and Health Vulnerabilities in November 1993 (DOE 1993a). This evaluation was followed by a Plan of Action to Resolve Spent Nuclear Fuel Vulnerabilities in February 1994, which identified three phases to resolve those vulnerabilities (DOE 1994a). This Phase I Action Plan, which addresses the most urgent activities, was issued immediately. The Phase II Action Plan was released April 1994 for public comment (DOE 1994b). The Phase III plan was issued in October 1994 (DOE 1994c). Phases I, II, and III corrective actions include activities at the main DOE SNF storage sites. Examples of corrective action projects include installing equipment to improve storage pool water quality at the Savannah River Site; transferring fuel from an old, inadequate water pool to a newer pool at the Idaho National Engineering Laboratory; removal of all fuel and sludge from the 105-K basins at the Hanford Site.

Some of the SNF Action Plan activities could potentially result in emission and effluents. These effects are not individually analyzed because their impacts are no greater than the impacts of normal SNF management activities reported and analyzed for each site in Volume 1 and the respective site appendices.
Successful completion of the corrective actions would reduce the potential for health and safety problems to the workers and public and minimize degradation to the environment.

In addition to the Spent Fuel Working Group report on vulnerabilities and the associated plans of action to resolve the identified vulnerabilities, the Defense Nuclear Facilities Safety Board issued Recommendation 94-1 (Conway 1994) calling for DOE to develop an expedited schedule for resolving identified vulnerabilities across the DOE complex. Recommendation 94-1 was critical of DOE's lack of urgency in correcting known SNF management deficiencies. Further, Recommendation 94-1 criticized DOE's lack of prioritization of corrective actions and lack of an integrated systems approach to resolving previously identified SNF management issues. DOE has developed a plan for implementing Recommendation 94-1 across the DOE complex. DOE's Implementation Plan (DOE 1995a) for Recommendation 94-1 was submitted to the Defense Nuclear Facilities Safety Board on February 28, 1995. The plan includes a prioritization of corrective actions to remedy known deficiencies utilizing a DOE complex-wide systems approach and considering limited budgets. The plan focuses on fulfilling outstanding commitments to other parties (for example, court-ordered milestones) and fully recognizes the urgency required to rectify long-standing SNF management issues.

1.1.2 DOE Spent Nuclear Fuel Management

For the purposes of this document, SNF is separated into two categories: commercial SNF and DOE-managed SNF. The management of commercial SNF (with a few special-case exceptions) is outside the scope of this SNF and INEL EIS and is not discussed further herein.

Since 1943, DOE and its predecessor agencies have generated more than 100,000 metric tons of heavy metal (MTHM) of SNF, of which about 2,700 metric tons remains. This SNF was generated in various programs in different types of reactors, including DOE defense production reactors, United States naval reactors, and DOE test and experimental reactors. In addition, DOE has accepted responsibility for SNF from non-DOE sources, including United States university research reactors, special-case commercial power reactors, and selected foreign research reactors.

In 1992, the Secretary of Energy directed the DOE to develop an integrated, long-term SNF management program. This program is assessing DOE's SNF and fuel storage facilities, integrating DOE's many existing SNF activities into one program, deciding the most appropriate and responsible means of facility operation, and ensuring that issues associated with SNF are resolved safely and cost effectively. Solutions to the storage questions may require changes in the management strategies for these fuels, including such options as the construction of new facilities and stabilization of certain fuels. The program has also established a programmatic objective to define a management path and proceed toward ultimate disposition of DOE-managed SNF, as outlined in DOE (1994d). A number of activities are currently in process to meet or address this objective. Appendix J, Spent Nuclear Fuel Management, provides an overview of technologies for SNF management.

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a. The Atomic Energy Act of 1954, as amended, gives DOE the responsibility and ultimate title for the Nation's SNF. The Nuclear Waste Policy Act of 1982, as amended sets up the process for disposition of the Nation's commercial nuclear power reator SNF in a mined geologic repository and makes provisions for cost recovery for the ultimate disposition of that SNF. It also specifies the procedures for ultimate disposition of DOE's high-level waste and SNF.

b. Quantities of fresh nuclear fuel, SNF, and targets are traditionally expressed in terms of metric tons of heavy metal (typically uranium), without the inclusion of other materials, such as cladding, alloy materials, and structural materials. A metric ton equals approximately 2,200 pounds.

For various reasons, including the lack of characterization data on the interim storage behavior of certain SNF types and the fact that the acceptance criteria for ultimate disposition have not yet been defined, DOE cannot yet make all the decisions for the full 40-year period. Therefore, this EIS focuses on issues relating to deciding the locations of future SNF management activities.

DOE faces a number of major programmatic and site-specific decisions regarding SNF management over the next 40 years including

Where should DOE locate specific SNF management activities? Broadly, the alternatives include managing the SNF where it is and minimizing shipments; consolidating the SNF at a limited number of sites (the Decentralization, 1992/1993 Planning Basis, and Regionalization 4A and 4B alternatives); or consolidating the SNF at a central site.

What capabilities, facilities, and technologies are needed for SNF management? DOE has identified the need for SNF interim storage sites and must select appropriate means at each site for meeting these needs under each of the SNF siting alternatives.

What research and development activities should support the SNF management program?

1.1.2.1 Current and Projected Spent Nuclear Fuel Inventories.

Table 1-1 summarizes the current inventories of SNF at DOE and other facilities and those projected to be generated through the year 2035. These estimates are based on assumptions regarding reasonably foreseeable future reactor operations and the generation rates of SNF for which DOE is responsible. The principal SNF generators and storage sites for SNF are described below and in Appendices A through F. Figure 1-2 illustrates those locations, as well as representative points of entry for foreign fuels under consideration in this EIS.

1.1.2.2 DOE Facilities.

During the last four decades, DOE and its predecessor agencies have transported, received, reprocessed, and stored SNF at various facilities in the nationwide DOE complex. Three of the DOE facilities have primary responsibility for managing DOE SNF; several others have smaller roles in SNF management.

Table 1-1. Spent nuclear fuel inventory.[a]

Generator or storage site[b]	Existing (1995)		Future increases (through 2035)		Total (2035)	
Generator or storage site[b]	MTHM[c]	Percent	MTHM[c]	Percent	MTHM[c]	Percent
DOE Sites						
Hanford Site	2132.44	80.6	0.00	0.0	2132.44	77.8
Idaho National Engineering Laboratory	261.23	9.9	12.92	13.5	274.14	10.0
Savannah River Site	206.27	7.8	0.00	0.0	206.27	7.5
Oak Ridge Reservation	0.65	<0.1	1.13	1.2	1.78	<0.1
Other DOE Sites	0.78	<0.1	1.50	1.6	2.28	<0.1
Naval Nuclear Propulsion Reactors	0.00[d]	0.0	55.00	57.6	55.0	2.0
Foreign Research Reactor	0.00	0.0	21.70	22.7	21.70	0.8
Non-DOE Domestic						
Domestic Research and Test Reactors[e]	2.22	<0.1	3.28	3.4	5.50	0.2
Special-Case Commercial SNF at non-DOE locations[f]	42.69	1.6	0	0	42.69	1.6
Total[g,h]	2646.27		95.53		2741.80	
Percent of 2035 total	96.5		3.5		100.0	

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a. Source: Wichmann (1995). Changes to the spent nuclear fuel (SNF) inventory contained in the Draft Environmental Impact Statement were made to reflect updated inventories at domestic research and test reactors and to remove materials that are contact-handled (i.e., materials unirradiated or slightly irradiated).

b. The Nevada Test Site does not currently store or generate SNF and is not expected to generate SNF through 2035.

c. MTHM = metric tons of heavy metal. One MTHM equals approximately 2,200 pounds.

d. Existing inventory of naval SNF (10.23 MTHM) is included in the Idaho National Engineering Laboratory totals.

e. Includes research reactors at commercial, university, and government facilities.

f. The total inventory of SNF from special-case commercial reactors is 186.41 MTHM. The 42.69 MTHM indicated here is just that stored at the Babcock & Wilcox Research Center, Fort St. Vrain Reactor, and West Valley Demonstration Project. The remaining special-case commercial SNF is stored at the Idaho National Engineering Laboratory, Oak Ridge Reservation, Hanford Site, and Savannah River Site and is included in the totals (in this table) for those sites.

g. Changes to the fuel inventory occurred due to recalculation of the Idaho National Engineering Laboratory inventory at the Experimental Breeder Reactor-II and Hot Fuel Examination Facility and the removal of contact-handled fuel.

h. Numbers may not sum due to rounding.

Figure 1-2. Locations of principal spent nuclear fuel generators and storage sites.

Hanford Site-The Hanford Site was dedicated to producing plutonium for more than 40 years, until production was halted in 1989. Hanford's production reactors (including the N Reactor and Single-Pass Reactor) have generated 2100 MTHM of the existing DOE SNF. The ongoing actions at Hanford are focused on improving worker health and safety and protecting the environment. SNF management activities include reducing water contamination levels, performing physical upgrades necessary to assure facility safety for near-term storage, characterizing SNF condition, and stabilization or repackaging for storage and/or ultimate disposition.

The SNF at facilities associated with the Hanford Site include N-Reactor SNF, Single-Pass Reactor SNF, Shippingport Core II SNF, Fast Flux Test Facility SNF, and miscellaneous special-case commercial and experimental SNF. As shown in Table 1-1, the Hanford Site currently stores over 80 percent (by MTHM) of the current complex-wide SNF.

Idaho National Engineering Laboratory-The Idaho National Engineering Laboratory is one of the principal centers in the DOE complex for nuclear research and development. Ongoing activities include continued safe storage of SNF, continued reactor operations, and onsite fuel transfers to reduce identified vulnerabilities.

As a result of its historic mission, the Idaho National Engineering Laboratory has been safely managing SNF for over 40 years. This site is the home of the Expended Core Facility and the Naval Reactors Facility, which are central to the Navy's nuclear propulsion program. Currently, the site stores approximately 261 MTHM (about 10 percent) of DOE's SNF from a variety of DOE programs and a limited number of commercial and foreign sources.

Savannah River Site-The Savannah River Site was constructed in the early 1950s to produce the basic materials used in nuclear weapons-primarily plutonium and tritium.

Savannah River's production reactors have generated about 150 MTHM of the existing DOE SNF. Most of the SNF from Savannah River Site reactor operations is stored underwater in concrete, water-filled reactor storage basins. These reactor disassembly basins were originally intended for only short-term storage of production reactor SNF. Some of the SNF stored at Savannah River consists of uranium clad in stainless steel or zirconium alloy, which Savannah River Site cannot process without facility modifications. Ongoing activities include improving the use of existing storage facilities to provide for continued safe storage of the less corrosion-resistant aluminum-clad SNF. DOE currently manages approximately 206 MTHM (about 8 percent) of its SNF at the Savannah River Site.

Oak Ridge Reservation-The Oak Ridge Reservation was originally developed as part of the Manhattan Project-the effort to build the first nuclear weapons. The missions of Oak Ridge Reservation facilities include weapons dismantlement, storage of enriched uranium, maintaining production capability, technology research and development, and environmental management. Less than 1 MTHM (0.07 percent) of DOE's SNF is either in storage or being generated at several facilities at the Oak Ridge Reservation.

Other Department of Energy Sites-A number of other DOE sites also store SNF, principally from experimental and test reactors that have operated at many Department sites nationwide. Four of these DOE sites storing SNF are as follows:

Argonne National Laboratory-East has one reactor that is being decontaminated and decommissioned. This site currently manages 0.08 MTHM of SNF.

Brookhaven National Laboratory is generating and storing SNF at two facilities. The Brookhaven High Flux Beam Reactor and the Brookhaven Medical Research Reactor are both operating at the present time. This site currently manages 0.24 MTHM of the DOE's SNF.

Los Alamos National Laboratory has SNF at the Omega West Reactor, which has been shut down since December 1992. There is 0.014 MTHM of SNF in storage at Los Alamos.

Sandia National Laboratories have reactors that operate as needed. These reactors will generate small quantities (0.4 MTHM) of SNF when shut down and defueled.

1.1.2.3 Navy Nuclear Propulsion Program.

Naval SNF is removed from naval reactors at shipyards and prototype sites and placed in shielded shipping containers. Since 1957, the SNF removed from nuclear-powered naval vessels and prototypes has been transported from shipyards and prototype sites to the Naval Reactors Facility at the Idaho National Engineering Laboratory. The SNF is then removed from the shielded shipping containers and placed into a water pool at the Expended Core Facility. In the water pool, each naval fuel assembly receives, as a minimum, an internal and external visual examination to confirm that it performed as designed and to identify anomalies that would warrant more detailed examination. After examination, the SNF is loaded into shielded containers and transferred to the Idaho Chemical Processing Plant for storage.

Currently, four naval shipyards and one commercial shipyard (Norfolk, Puget Sound, Portsmouth, Pearl Harbor, and Newport News) and the Kesselring Site support the refueling of nuclear-powered ships and prototypes. Other naval shipyards that formerly supported defuelings and refuelings, such as Charleston and Mare Island, are being closed because of military base closure decisions. An existing water pool facility, constructed to support the refueling of nuclear-powered aircraft carriers, is located within the industrial zone of the Puget Sound Naval Shipyard. To date, the facility has been used for refueling equipment demonstrations and testing. The facility contains a radiologically controlled, high bay structure and a Personnel Support Building, which provides office and other nonradiological support functions. The high bay structure contains the water pool and general work areas. At Newport News, SNF is removed from naval vessels and temporarily stored near the removal site before transport.

1.1.2.4 Foreign Research Reactors.

In accordance with national nuclear nonproliferation goals, DOE has accepted (and is considering the renewal of the policy to accept) SNF that contains enriched uranium of United States origin that was used in foreign research reactors. In April 1994, DOE decided to accept up to 409 additional SNF elements from eight foreign research reactors in seven European countries for storage at the Savannah River Site. One hundred fifty-three of these elements were actually received before an order by the court in the case of South Carolina v. O'Leary, No. 3:94-2419-0 (District of South Carolina January 27, 1995) preventing the receipt of additional shipments. That order is currently on appeal to the United States Court of Appeal for the Fourth Circuit. The United States Government is currently considering the acceptance of SNF from approximately 40 nations. This foreign research reactor SNF is estimated to amount to 21.7 MTHM and is the subject of the Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel (see Section 1.2.5), due to be published in 1995.

1.1.2.5 Non-DOE Domestic.

This category includes non-DOE domestic, licensed facilities, including training, research, and test reactors at university, commercial establishments, and government-owned installations for which DOE has contractual obligations to accept SNF. Appendix E provides additional detail on these sites. These locations currently have less than 1 percent of the existing DOE SNF.

Domestic Research and Test Reactors-Fifty-seven domestic non-DOE facilities have been licensed by the U.S. Nuclear Regulatory Commission, 38 of which are expected to be small generators of DOE SNF during the next 40 years. These facilities include colleges, universities, government, and commercial establishments in the United States that use reactors for educational and research activities. The reactors are of several different types and are used for training, experimentation, and teaching in nuclear science and engineering. Some of these research sites have limited storage capacity compared with generation rates. Table 1-2 provides a summary of these locations, the SNF currently at these locations, and the amount of SNF they currently have stored plus projected generation through the year 2035.

Special-Case Commercial Power Reactors-DOE also has taken possession of SNF assemblies and complete or sectioned SNF rods from various commercial nuclear power reactors that were to be used to support DOE-sponsored research and development programs. By way of a three-party agreement among the Public Services Company of Colorado, General Atomics, and the Atomic Energy Commission, the DOE has agreed to provide dry storage at the Idaho National Engineering Laboratory for eight segments of Fort St. Vrain SNF (approximately 1,920 SNF elements). Three segments of this SNF have been transported to the Idaho National Engineering Laboratory; the other five are currently being stored at the Fort St. Vrain site. Other SNF in this category includes SNF from development reactors (Shippingport and Peach Bottom Unit 1); SNF used for destructive and nondestructive examination and testing; SNF remaining at the West Valley Demonstration Project; SNF from fuel performance testing at the Babcock & Wilcox Research Center; and special-case SNF debris (Three-Mile Island Unit 2).

Table 1-2. Summary of domestic research and test reactors.

Type	Number of locations	MTHM[a] (ROD[b])	MTHM[a] (2035)
Universities[c]	29	2.01	4.96
Government, non-DOE[c]	5	0.11	0.42
Commerical[c]	4	0.10	0.12
Total	38	2.22	5.50

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a. MTHM = metric tons of heavy metal.
b. ROD = Record of Decision, June 1995.
c. See Appendix E of Volume 1 of this EIS for a discussion of these locations.

Table 1-3 summarizes the types and quantities of special-case commercial power reactor SNF in storage. This SNF currently is in storage at either the West Valley Demonstration Project in West Valley, New York, the Babcock & Wilcox Research Center in Lynchburg, Campbell County, Virginia, or the Fort St. Vrain facility in Colorado. Additionally, special-case commercial SNF (such as from Three-Mile Island, Peach Bottom, and Shippingport) is also stored at the Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, and Oak Ridge Reservation.

1.1.3 Technologies for the Management of Spent Nuclear Fuel

DOE must safely manage SNF until its ultimate disposition. Some SNF, such as naval reactor fuel, was designed for long-term operation and to survive combat conditions; therefore, it is rugged enough to retain its integrity during prolonged storage. Commercial reactor fuel is also inherently stable and suitable for prolonged storage. The DOE will not select SNF technologies on the basis of Volume 1 of this EIS. These technology-based decisions are most appropriately dealt with on a fuel type-specific or site-specific basis.

Table 1-3. Special-case commercial power reactor spent nuclear fuel (SNF).

Storage location	Category	SNF in storage[a]	MTHM[b]
West Valley, NY	Light-water reactor fuel	125 elements	

			27
Lynchburg, VA	Light-water reactor partial fuel elements	3 full-length rods and 17 sectioned rods	0.044
Fort St. Vrain, CO	High-temperature gas-cooled reactor fuel	1,464 elements	16

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a. No additions projected through 2035.
b. MTHM = metric tons of heavy metal. One MTHM equals approximately 2,200 pounds. (The approximate total of SNF currently at these locations is 43 MTHM.)

1.1.3.1 Storage.

Interim storage may be accomplished with either dry or wet storage technology. Wet storage normally involves the use of belowgrade water-filled pools. Dry storage places the SNF in a shielded container for aboveground storage. Dry storage technologies range from the use of casks, which hold only a few fuel elements, to vaults that are capable of holding a large quantity of fuel. Casks are normally constructed of steel or reinforced concrete, and vaults are normally constructed of concrete. For dry storage, a number of similar concepts have been used for commercial power reactor-type fuels and may be suitable for some of the DOE SNF. While both wet and dry storage are being evaluated for SNF management, dry storage has several unique advantages when heat dissipation is not a major concern. These advantages include lower emissions, simpler operation, lower cost, shorter times for design and construction, and capability for licensing by the U.S. Nuclear Regulatory Commission, if required.

1.1.3.2 Stabilization.

Stabilization may be necessary to provide safe interim storage of SNF. Stabilization technologies can be placed in three broad categories: containerization, processing without fissile material separation, and processing with fissile material separation. Containerization can involve processes such as canning, coating, and passivation. Canning involves placing the fuel in a sealed canister of durable construction (such as stainless steel). Coating involves depositing a protective film on the fuel to inhibit corrosion. Passivation involves treating the SNF to place exposed surfaces in a less reactive form when the SNF is stored in either water or air.

Processing without fissile material separation involves processes such as direct dissolving of the fuel elements or oxidation of the fuel elements. Oxidation involves separation of the fuel matrix from the cladding using oxygen at elevated temperatures [up to 800C (1,472F)]. The principal existing approach for processing with fissile material separation is aqueous processing. Aqueous processing involves breaking down the fuel through mechanical means (shearing, chopping, cutting) or chemical means (acid or electrolytic dissolution, combustion, hydrolysis) and then chemically separating the fuel constituents by solvent extraction. Aqueous processing would normally be followed by a vitrification process where the high-level waste is processed into a glass or ceramic form. The Savannah River Site currently has the capability to process aluminum-clad fuel.

Appendix J provides more details on fuel management technologies. Appendices A through F provide details on the storage and stabilization technologies evaluated for each of the potential SNF management sites. These technologies are representative of those discussed above. This EIS evaluates the environmental impact of these technologies to illustrate, at a programmatic level, the characteristic impacts from implementing each programmatic alternative.

The DOE will conduct additional National Environmental Policy Act reviews for research and development and characterization activities that help select technologies for placing the SNF in a form suitable for interim storage and ultimate disposition.

1.1.3.3 Transportation.

Depending on the SNF management options selected, some of the SNF may be moved one or more times before being transported. SNF is transported in massive, lead and steel shielded casks that can weigh above 100 tons. These casks must conform to both U.S. Nuclear Regulatory Commission and U.S. Department of Transportation regulations. Shipment by both rail cars and trucks is common, with the chief advantage of rail being the ability to transport heavier, more massive casks and, thus, transport more SNF per shipment.

The casks serve two functions: (a) providing gamma radiation shielding from the SNF so that the radiation level outside the casks meets regulatory requirements, and (b) providing protection to and containment of the SNF even in case of accidents. The casks are designed to withstand a wide range of very severe accidents. Because the SNF is generally metallic in form, most of the radionuclides stay within the metal fuel even in maximum foreseeable transportation accidents. The risks to both workers and the public have been evaluated many times, most recently in Appendix I of this EIS, and have been shown to be low.

1.1.3.4 Ultimate Disposition.

In the Nuclear Waste Policy Act, as amended, Congress established a national policy for disposal of high-level waste and commercial SNF in a geologic repository, and directed DOE to characterize the Yucca Mountain site in Nevada for suitability as the site of a first United States repository. That Act authorizes disposal of DOE SNF, as well as commercial spent fuel, in the first repository, subject to a limit on repository capacity and the payment of appropriate fees. For planning purposes, the DOE assumes that some or all of the SNF in its inventory that satisfies the repository's acceptance criteria could be placed in the first geologic repository developed under the Nuclear Waste Policy Act of 1982, as amended.

Although beyond the scope of this EIS, two broad strategies may at this point be envisioned for the ultimate disposition of DOE SNF. The DOE could (a) work toward direct disposal of SNF in a geologic repository, or (b) chemically dissolve the fuel and produce a waste form (such as vitrified glass) for repository disposal. Variations on these broad strategies are also possible, and both remain under consideration. It is possible that some of DOE's SNF could qualify for direct disposal. Aggressive characterization and, if appropriate, preparation programs would be necessary, and would need to be coordinated with plans to develop one or more repositories.

Sufficient quantity and quality of information is still not available to determine at this time whether the Yucca Mountain site is a suitable candidate for geologic disposal of SNF and high-level radioactive waste. The DOE, however, is in the early planning stages for a repository EIS, which will be prepared pursuant to the directives of the Nuclear Waste Policy Act of 1982, as amended. The DOE plans to issue in mid-1995 a formal notice of its intent to prepare this analysis. The repository EIS is being prepared to evaluate potential environmental impacts, based on the best available information and data, that would be associated with the repository's development and operation, and to support the Secretary of Energy's final recommendation to the President, as required by the Nuclear Waste Policy Act of 1982, as amended. The repository EIS will examine the site-specific environmental impacts from construction, operation, and eventual closure of the repository, including potential post-closure radiological effects to the environment. Until the repository EIS is complete, no final decision could be made concerning what DOE SNF would be accepted in a geologic repository.

As part of its SNF management program, DOE would (a) stabilize the SNF as needed to ensure safe interim storage, (b) characterize the existing SNF inventory to assess compliance with the repository acceptance criteria as they are developed, and (c) determine what processing, if any, is required to meet the criteria. Decisions regarding the actual disposition of DOE's SNF would follow appropriate review under the National Environmental Policy Act, and would be subject to licensing by the U.S. Nuclear Regulatory Commission. This "path forward" would be implemented so as to minimize impacts on the first repository schedule. The current planning assumption is that any DOE material (vitrified high-level waste and/or SNF) qualified and selected for emplacement in the first repository would be disposed beginning in the year 2015. Disposition of the remaining DOE SNF and vitrified high-level waste that is not emplaced in the first repository would not be decided until the DOE recommendation on the need for a second repository (which would consider such factors as the physical and statutory limits of the first repository). The Nuclear Waste Policy Act of 1982, as amended, requires DOE to make that recommendation between January 1, 2007, and January 1, 2010.

Except perhaps for a need to develop them further, the technologies described above for stabilization and safe storage are available for the management of SNF and appear adequate to meet the needs of ultimate disposition. Disposal in a repository, for example, may require canning, canisterization, encapsulation, or processing the fuel to create a vitrified waste form. Resource recovery requires dissolving the fuel to separate the fissile material from the waste and producing a stable waste form. These required technologies have already been applied and are under continued development in several countries. Once the acceptance criteria are established, the appropriate technologies can be identified and finalized to ensure that the SNF can be put in an acceptable form for ultimate disposal.

1.2 Relationship to Other

National Environmental Policy Act Documents

DOE currently has a range of National Environmental Policy Act reviews planned or under way that are interrelated with or tier from this SNF management review. Because the scope of SNF management includes a wide variety of proposals, multiple National Environmental Policy Act reviews are, or will be, necessary. Related reviews are identified in Table 1-4. Figure 1-3 graphically presents the interrelationships of the various National Environmental Policy Act reviews. Discussion in the following subsections centers primarily on reviews with an interrelationship with this SNF management review. The remaining documents in Table 1-4 are site-specific reviews of SNF management, or individual project reviews that have a relationship to SNF management.

Table 1-4. Major National Environmental Policy Act (NEPA) reviews related to Volume 1 of this Environmental Impact Statement (EIS) as of March 1995.

Site	Type of NEPA Review	Subject	Status
DOE		Waste Management Programmatic EIS	

(Headquarters)	EIS		In preparation
	EIS	Programmatic EIS for Tritium Supply and Recycling[a]	In preparation
	EIS	Stockpile Stewardship and Management EIS	Future
	EIS	EIS for a potential repository at Yucca Mountain for disposal of high-level radioactive waste	Future
	EIS	EIS on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel	In preparation
	EIS	Storage and Disposition of Weapons-Usable Fissile Materials	In preparation
	EIS	Fabrication and Deployment of a Multi-Purpose Canister-Based System for the Management of Civilian Spent Nuclear Fuel	In preparation
U.S. Navy	EA/FONSI[b]	Short-Term Storage of Naval Spent Nuclear Fuel (SNF)	Issued
West Valley Demonstration Project	EA	Management of SNF in Storage at the West Valley Demonstration Project (interim onsite dry storage)	In preparation
	EIS	West Valley Demonstration Project Completion and Site Closure	In preparation
Savannah River	EA/FONSI	Urgent-Relief Acceptance of Foreign Research Reactor SNF[c]	Issued
	EIS	Interim Management of Nuclear Materials at Savannah River Site	In preparation
Oak Ridge Reservation	EA/FONSI	High Flux Isotope Reactor SNF storage reracking	Issued
	EA	High Flux Isotope Reactor Dry Storage Pad	Future
Idaho National Engineering Laboratory	EIS	Programmatic SNF and Idaho National Engineering Laboratory Environmental Restoration and Waste Management, Volume 2	In preparation
	EA/FONSI[d]	Fort St. Vrain Fuel Shipments to the Idaho Chemical Processing Plant	Issued
	EA	Test Area North Pool Stabilization Project (also known as Dry Cask Storage Project)	In preparation
Nevada Test Site	EIS	Nevada Test Site and Other Off-Site Test Locations Within the State of Nevada Site-Wide EIS	In preparation
Hanford Site	EA/FONSI	105-KE and 105-KW Basins Fuel Encapsulation and Repackaging, 100-K Area	Issued
	EA	Transfer of Plutonium Uranium Extraction Plant and N-Reactor Irradiated Fuel for Encapsulation and Storage at the K-Basins	In preparation
	EA	Shutdown of the Fast Flux Test Facility	In preparation
	EA	Relocating TRIGA[e] Reactor Fuel from 308 Building (covers SNF, lightly irradiated fuel, and unirradiated fuel)	In preparation
	EA	Characterization of Stored Defense Production SNF and Associated Materials at Hanford Site, Richland, Washington	In preparation
	EIS	Hanford SNF Management EIS	Future
	EIS	Preparation of an EIS for Management of SNF from the K-basins at the Hanford Site, Richland, Washington	In preparation

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a. The Nuclear Weapons Complex Reconfiguration Study was replaced by two separate National Environmental Policy Act reviews: the

Programmatic EIS for Tritium Supply and Recycling and the Stockpile Stewardship and Management Programmatic EIS.

b. Environmental Assessment (EA): A concise public document provided by a Federal agency that presents evidence and analysis for determining whether to prepare an EIS or a Finding of No Significant Impact (FONSI).

c. After the FONSI was issued, one shipment of foreign research reactor fuel was actually received in the U.S. A lawsuit by the State of South Carolina resulted in an order preventing the receipt of additional shipments (South Carolina v. O'Leary, No. 3:94-2419-0 (D.S.C. January 27, 1995). That order is currently on appeal to the United States Court of Appeal for the Fourth District.

d. The EA and FONSI were determined by the District Court to be inadequate. Volumes 1 and 2 of this EIS address shipments of Fort St. Vrain fuel.

e. TRIGA: Training, research, and isotope reactors built by General Atomics.

Figure 1-3. Interrelationships of National Environmental Policy Act reviews related to SNF management. Volume 1 of this EIS provides the overall programmatic National Environmental Policy Act review of the management of DOE SNF. This review and the Record of Decision will be summarized and incorporated in the DOE Waste Management Programmatic EIS, currently in development. Programmatic reviews for nuclear weapons disposition and weapons-usable fissile materials will also provide input to the DOE Waste Management Programmatic EIS. This SNF EIS will provide input to the EIS for the management of SNF from foreign research reactors. Except for special-case commercial reactors, commercial SNF is not evaluated in this SNF EIS. DOE is also preparing an EIS for a multipurpose canister system. Additional National Environmental Policy Act reviews for DOE and commercial SNF will be prepared as needed.

Table 1-4 and Figure 1-3 also identify site- or project-specific National Environmental Policy Act reviews currently planned or underway. This Volume 1 is a DOE-wide programmatic EIS covering a full range of strategic alternatives for the management of SNF. As such, this document is an upper tier EIS, intended to provide National Environmental Policy Act review of related and potential actions. By tiering National Environmental Policy Act documentation, DOE is able to look at the overall potential impact of a group of connected actions. Lower-tier reviews provide more specific and detailed analyses on specific sites and projects that stem from the programmatic decisions. The tiering of National Environmental Policy Act reviews as they relate to this SNF management review is shown schematically in Figure 1-3. This programmatic EIS does not replace site-specific or project-specific National Environmental Policy Act documentation, except where adequate coverage is provided in this EIS to evaluate reasonably foreseeable impacts. For the Idaho National Engineering Laboratory, the site-specific documentation is provided by Volume 2 of this EIS.

1.2.1 Waste Management Programmatic Environmental Impact Statement

DOE is currently analyzing nationwide and site-specific alternative strategies to maximize efficiency for DOE's waste management program. The nationwide analyses will be part of the DOE Waste Management Programmatic Environmental Impact Statement (PEIS) (previously known as the Environmental Management Programmatic Environmental Impact Statement). This PEIS evaluates proposed DOE actions regarding the

Type, size, and number of waste storage, treatment, and disposal facilities needed and where to build them, including the transportation network

Proposed action formulating and implementing an integrated Waste Management Program

Alternative configurations for each waste type (except hazardous waste) to provide a framework for siting future facilities at specific locations.

The alternatives are structured to ensure analysis of the impacts of the mixed waste configuration that will be defined in the site treatment plans developed pursuant to the Federal Facility Compliance Act.

The Draft Waste Management PEIS is scheduled to be available for public and agency review and comment by mid-1995. Although the DOE Waste Management PEIS was originally intended to provide the programmatic analyses of alternatives for SNF management, these analyses are also presented in this volume. The Waste Management PEIS is expected to summarize and consider, as part of its analysis of cumulative environmental consequences, the impacts of the SNF alternatives identified in this EIS.

1.2.2 Programmatic Environmental Impact Statement for Tritium Supply and Recycling

The Nuclear Weapons Complex Reconfiguration Program has evolved considerably since its original Notice of Intent to prepare a Nuclear Weapons Complex Reconfiguration PEIS was issued in February 1991. DOE has now separated the Nuclear Weapons Complex Reconfiguration EIS into two programmatic EISs: (a) a PEIS for Tritium Supply and Recycling (expected completion in November 1995) and (b) a Stockpile Stewardship and Management PEIS. In the original Notice of Intent, DOE proposed to reconfigure the Nation's nuclear weapons complex to be smaller, less diverse, and less expensive to operate. This proposal offered the advantage of enabling the closure and remediation of the Mound and Rocky Flats Plants. At that time, no new plutonium or highly enriched uranium storage facilities were envisioned, and a new tritium production facility was being planned as part of a separate New Production Reactor Program. Later, the New Production Reactor Program was incorporated into the Reconfiguration PEIS. DOE's needs have evolved since then for many reasons, but primary among them is the end of the Cold War. The tangible effects of this include the significant reduction in the size of the Nation's stockpile of nuclear weapons and reduced requirements for production of tritium.

Accordingly, the Tritium Supply and Recycling PEIS addresses alternatives associated with new tritium production and the recycling of tritium recovered from weapons being retired from the stockpile. Alternative technologies for producing tritium are planned to be analyzed at five candidate sites (Savannah River Site, Oak Ridge Reservation, the Pantex Plant, the Idaho National Engineering Laboratory, and the Nevada Test Site). The PEIS was issued in draft form February 28, 1995.

1.2.3 Stockpile Stewardship and Management Environmental Impact Statement

The Stockpile Stewardship and Management Environmental Impact Statement was originally part of the Nuclear Weapons Complex Reconfiguration Programmatic Environmental Impact Statement (see Section 1.2.2). DOE expects to begin the scoping process for the Stockpile Stewardship and Management PEIS in 1995. Stockpile stewardship includes activities required to maintain a high level of confidence in the safety, reliability, and performance of nuclear weapons in the absence of underground testing, and to be prepared to test weapons if directed by the President. Stockpile management activities include maintenance, evaluation, repair, or replacement of weapons in the existing stockpile. The review will take into account the latest information on current and projected future stockpile requirements.

1.2.4 Storage and Disposition of Weapons-Usable Fissile Materials Programmatic

Environmental Impact Statement

In response to the President's Nonproliferation and Export Control Policy issued on January 24, 1994, the Department created a separate Department-wide project for developing recommendations and for directing implementation of decisions concerning disposition of excess nuclear materials. Through this PEIS, DOE proposes to develop a comprehensive national policy for the management and disposition of fissile materials (primarily separated plutonium and highly enriched uranium, but also other excess nuclear materials including neptunium, americium, and uranium-233) that are no longer required for military purposes.

1.2.5 Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research

Reactor Spent Nuclear Fuel Environmental Impact Statement

DOE proposes to adopt and implement a policy concerning management of SNF containing enriched uranium that originated in the United States and was used by foreign research reactors. Under the proposed policy, the United States may manage approximately 22,750 elements (19.2 MTHM) of high-enriched uranium or low-enriched uranium SNF during a 10-year period from foreign research reactors in approximately 40 nations. Alternative methods of implementing the proposed action and the No Action alternative are being analyzed in an EIS. DOE will not make a final decision on the acceptance of SNF from these foreign research reactors until after the EIS for the Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor SNF and this programmatic SNF EIS are both completed. Both of these EISs are scheduled to be completed in 1995.

The proposed action would support the nuclear nonproliferation policy of the United States by removing the highly enriched uranium from these reactors from international commerce. The implementation of this policy could result in the receipt of foreign research reactor SNF at one or more United States points of entry and overland transport to one or more DOE sites for storage and/or processing.

1.2.6 Fabrication and Deployment of a Multipurpose Canister-Based System for the

Management of Civilian Spent Nuclear Fuel Environmental Impact Statement

This environmental impact statement is addressing the potential environmental impacts associated with alternative systems for storage and transport of SNF assemblies for civilian and naval SNF. The review will analyze the following: (a) manufacturing of multipurpose canister system components, (b) packaging and handling of SNF as it is transferred to canisters or casks, (c) canister transfer and loading operations, (d) storage of SNF in canisters and casks at the reactor sites, (e) SNF transport from the reactor sites to a hypothetical monitored retrievable storage facility and/or repository, (f) handling and storage of SNF at a hypothetical monitored retrievable storage facility, and (g) surface activities involving the handling and disposal of SNF at a repository.

The multipurpose canister-based technology may have application for DOE and Navy SNF.

1.2.7 Environmental Impact Statement for a Potential Repository at Yucca Mountain for

Disposal of High-Level Radioactive Waste

Under the Nuclear Waste Policy Act of 1982, as amended, DOE is investigating the suitability of the Yucca Mountain, Nevada, site as the nation's first licensed geologic repository for SNF and high-level radioactive waste. The Nuclear Waste Policy Act of 1982, as amended, requires that DOE's recommendation of a repository site to the President must be accompanied by an EIS. DOE has tentatively scheduled the Notice of Intent for the repository EIS for 1995 and the Record of Decision for 2000. Yucca Mountain is a potential disposal site for DOE SNF.

1.3 Scope of this Volume

1.3.1 Scoping Process

On October 22, 1990, DOE published a Notice of Intent in the Federal Register announcing its intent to prepare a PEIS addressing environmental restoration and waste management (including SNF management) activities across the entire DOE complex. DOE then invited the public to submit written comments on the scope of the PEIS, held 23 scoping meetings across the country, and issued a draft Implementation Plan in January 1992 reflecting the comments provided. DOE held six regional public workshops on the draft Implementation Plan and recorded public comments given at these workshops. The Implementation Plan for the PEIS was issued in January 1994 and addressed the comments received from scoping and the regional workshops.

On October 5, 1992, DOE published a Notice of Intent to prepare an EIS for Environmental Restoration and Waste Management at the Idaho National Engineering Laboratory in the Federal Register. The notice invited Government agencies and the public to participate in five scoping meetings throughout Idaho and to provide written comments. Oral testimony from the meetings was transcribed and made available at DOE public reading rooms. The comment period lasted from October 5, 1992, to December 4, 1992.

On September 3, 1993, DOE published a Notice of Opportunity to Comment in the Federal Register proposing to expand the scope of the Idaho National Engineering Laboratory Environmental Restoration and Waste Management EIS to include impacts related to transportation, receipt, processing, and storage of DOE SNF at locations other than the Idaho National Engineering Laboratory. This comment period started on September 3, 1993, and ended on October 4, 1993. Government agencies and the public were invited to provide comments on the DOE Programmatic SNF and the Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs EIS. A toll-free telephone number was provided for questions, requests for documents or other information, and for the public to provide oral comments that were transcribed for DOE's consideration. The Implementation Plan (issued October 29, 1993, and amended on May 9, 1994) for this EIS summarizes these comments and DOE's responses.

As existing large-scale SNF management operations, the Hanford Site at Richland, Washington; the Idaho National Engineering Laboratory in southeastern Idaho; and the Savannah River Site near Aiken, South Carolina, were logically identified as reasonable site alternatives for SNF management in the October 29, 1993, Implementation Plan. In addition, four Navy shipyards and the Kesselring Site (in West Milton, New York) with years of SNF handling experience were identified for consideration in the EIS for activities limited to naval SNF. The four Navy shipyards are the Norfolk Naval Shipyard, Portsmouth, Virginia; the Portsmouth Naval Shipyard, Kittery, Maine; the Pearl Harbor Naval Shipyard, Honolulu, Hawaii; and the Puget Sound Naval Shipyard, Bremerton, Washington.

In response to public scoping comments, DOE committed to consider other sites for SNF management in an effort to broaden the range of reasonable alternatives for locations at which SNF management activities could be conducted. DOE developed a screening process, which resulted in selection of the Oak Ridge Reservation, near Oak Ridge, Tennessee, and Nevada Test Site, near Mercury, Nevada, as additional site alternatives for regionalized or centralized SNF management (DOE-ID 1994). The EIS Implementation Plan was amended on May 9, 1994, to reflect this addition.

1.3.2 Scope

1.3.2.1 Programmatic Spent Nuclear Fuel Disposition.

The DOE will not analyze the ultimate disposition of SNF in this EIS. The focus of this Volume 1 of the EIS is the management of SNF in a safe and environmentally sound manner until decisions regarding its ultimate disposition are made and implemented. Decisions regarding the actual disposition of DOE's SNF will follow appropriate review under separate National Environmental Policy Act documentation. Congress has mandated that the Federal Government pursue the development of mined geologic repositories for the permanent disposal of SNF and high-level waste, and has directed DOE to study the Yucca Mountain, Nevada, site to determine whether it is a suitable site. Ultimate disposition of DOE SNF, however, is outside the scope of this programmatic SNF EIS.

1.3.2.2 Programmatic Spent Nuclear Fuel Stabilization.

DOE is phasing out reprocessing activities because of decreased demand for the recovery and reuse of certain nuclear materials. Fuel stabilization activities potentially required for safe interim storage and management of SNF, such as canning of some degraded fuels or processing as necessary, are relevant to the safe storage of SNF and within the scope of this EIS. Worker safety, public health, and potential environmental impacts associated with SNF stabilization, research and development of technologies, and pilot programs are topics of importance in analyzing the appropriate alternatives for interim storage of SNF and are included in this EIS.

In April 1992, the Secretary of Energy directed that DOE phase out defense-related chemical separations activities due to a reduction in the demand for new material for nuclear weapons (Claytor 1992). DOE no longer produces plutonium-239 and highly enriched uranium, and, in December 1994, DOE committed to prohibit the use of plutonium-239 and highly enriched uranium separated and/or stabilized during the phaseout, shutdown, and cleanout of weapons complex facilities for nuclear explosives purposes (Reis and Grumbly 1994). However, the use of chemical separations or other processing technologies is a reasonable site-specific option to assure the safe interim management of some types of SNF (or its constituents). Selection of chemical processing as a potential management option will be made after detailed analyses in site-specific National Environmental Policy Act reviews tiered from this EIS. Specific technologies for managing SNF are described in Volume 1, Appendix J. The potential impacts from a representative processing technology have been evaluated to aid in the analysis of reasonable technology options for interim storage of SNF and are included in this EIS. The DOE selected chemical separations for stabilization of degrading SNF as the technology for evaluation. The DOE believes the impacts from this activity are representative of the overall potential impacts of other similar technologies. This EIS assesses the impacts of processing only at the Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site because DOE determined it would require significant resources to consider undertaking such processing activities at sites with no facilities or infrastructure to support these processes. Processing operations that modify the SNF form to create new forms suitable for interim storage are much more complex than the activities associated with either dry storage or wet storage of intact SNF. For example, processing by chemical separation requires large-scale facilities for: SNF storage, SNF dissolution and chemical element separation operations, liquid high-level waste storage, storage for special nuclear material, and facilities to process the liquid high-level waste into a stable form, for example, vitrification, for storage. Additionally, all these facilities must be supported by a complex infrastructure of services and utilities. The Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site have some or all these facilities and all of the infrastructure for these types of operations. The other sites (that is, Nevada Test Site and Oak Ridge Reservation) lack this level of plant facilities or high-level waste infrastructure. The cost alone to create this level of capability makes evaluating the other sites less than desirable. Construction of the necessary high-level waste infrastructure is estimated to be several billion dollars.

1.3.2.3 Programmatic Spent Nuclear Fuel Storage.

Current and projected DOE SNF inventories are considered in this EIS. Existing storage facilities are identified, and their status, capacities, and accident histories are described. SNF container design, integrity, corrosion and corrosion byproducts, storage technologies, and storage facility design life are factored into the EIS analysis for each alternative. Storage options at the site of generation and other storage options are analyzed. The analysis of the storage options for each alternative includes the estimated type and size of representative storage facilities potentially needed at each site.

1.3.2.4 Programmatic Spent Nuclear Fuel Transportation.

The EIS includes an analysis of the potential impacts of SNF transportation, including safety and emergency preparedness requirements. A review of the safety record for past SNF transportation activity is included, along with an analysis of potential transportation impacts from normal transport and from transportation accidents.

Transportation modes and routes deemed reasonable for SNF shipment have been analyzed to estimate potential risks to worker safety, public health, and the environment. Federal and state regulations that place restrictions on certain aspects of SNF shipment and limits on shipment size, types of containers, and number of shipments have been accounted for in the analyses. Hazardous materials manifests, required for each shipment of SNF, include information on the carrier, the materials involved and their characteristics, and the containers.

The potential impacts of transporting nuclear fuel for ultimate disposition will be included in the appropriate National Environmental Policy Act documentation. Therefore, an alternative to transport SNF directly to a repository is not considered in this EIS.

1.3.2.5 Special-Case Commercial Fuels.

This EIS addresses the management of certain small quantities of special-case commercial SNF for which DOE has responsibility. Some of this SNF is currently being managed at DOE facilities; some is being managed at non-DOE facilities.

1.3.2.6 Naval Spent Nuclear Fuel.

This EIS addresses the impacts of and alternatives to transporting, receiving, and storing SNF from naval reactors (Navy warships and reactor prototypes) at a number of sites across the country, including sites near the point of refueling or defueling. The analysis includes alternative sites for naval fuel examination, as well as the possibility of phasing out this examination. This EIS addresses existing naval SNF inventories and fuel to be generated from future refuelings and defuelings.

1.4 Response to Public Comments

Volume 3, Response to Public Comments, was added to this EIS to fully address and respond to public comments. In addition, DOE considered public comments, along with other factors such as programmatic need, technical feasibility, and cost, in arriving at DOE's preferred alternatives. During the public comment period for the Draft EIS, more than 1,430 individuals, agencies, and organizations provided DOE with comments. A broad spectrum of private citizens; businesses; local, state, and Federal officials; Native American tribes; and public interest groups are represented within this volume of comments. Comments were received from all affected DOE and shipyard communities.

Volume 3 summarizes the comments on the EIS received by DOE during the public comment period and provides responses to those comments. In addition, Volume 3 explains how public comments influenced the selection of the preferred alternatives, discusses the extent to which public comments resulted in changes to the EIS, and describes how to find specific comment summaries and responses in this volume.

Responses to comments consist of two parts. The first part summarizes the comment(s), and the second part responds to the comment(s). Identical or similar comment(s) were frequently provided by more than one commentor and, in such cases, DOE grouped the comments and prepared a single response for each group. This summarization was also appropriate due to the large volume of comments received.

In compliance with National Environmental Policy Act and Council on Environmental Quality regulations, public comments on the Draft EIS were assessed and considered both individually and collectively by DOE and the Navy. Some comments resulted in modifications in the EIS or explanations of why comments did not warrant further response. Most comments not requiring a change to the EIS resulted in a response to correct factual misinterpretations, to explain or communicate government policy, to clarify the scope of the EIS, to explain the relationship of the EIS to other related policy, to clarify the scope of the EIS, to explain the relationship of the EIS to other related National Environmental Policy Act documentation, to refer commentors to information in the EIS, to answer technical questions, or to further explain technical issues. The Record of Decision will include the decision made by the Secretary of Energy, which will consider public comments on the Draft EIS.

1.4.1 How DOE Considered Public Comments in the National Environmental Policy Act Process

As required in the Council on Environmental Quality regulations [40 CFR 1502.14(e)], DOE's preferred alternatives are identified in the Final EIS. The preferred alternatives for Volumes 1 and 2 were identified based on the consideration of environmental impacts, regulatory compliance, DOE and SNF programmatic missions, public issues and concerns, national security and defense, cost, and DOE policy. Public input considered in the decisionmaking and preferred alternatives selection process included concerns, desires, and opinions regarding the activities addressed in the EIS and expectations of DOE in making the management decisions on complex-wide programmatic SNF management and environmental restoration and waste management programs at the Idaho National Engineering Laboratory. Public input contributed to the development of performance factors, defined as desirable attributes or characteristics that measure the relative acceptability of alternatives, which were used to select candidate preferred alternatives. The candidate preferred alternatives were then evaluated against a number of technical and nontechnical sensitivities, including public perception of environmental impact, indicated stakeholder preferences, implementation flexibility, regulatory risk, SNF processing potential, environmental justice, potential resistance to implementation, and fairness. DOE's preferred alternative reflects DOE consensus that SNF should be actively managed in preparation for ultimate disposition. In addition, DOE's preferred alternative supports the implementation of a path forward for the ultimate disposition of SNF, a significant issue raised by the public. The EIS, including its preferred alternatives, will be considered by the Secretary of Energy, along with other factors, in arriving at a decision to be documented in a formal Record of Decision.

1.4.2 Changes to the Environmental Impact Statement Resulting from Public Comment

A major purpose of the National Environmental Policy Act is to promote efforts that will prevent or eliminate damage to the environment by ensuring informed decisionmaking on major Federal actions significantly affecting the quality of the human environment. Consideration of public comments on the Draft EIS helps to ensure that the EIS is an adequate decisionmaking tool; accordingly, this EIS has been enhanced, as appropriate, in response to public comments. While a number of specific issues and concerns were raised by commentors, none of the issues or concerns identified new reasonable alternatives requiring assessment or resulted in significant change in the results of the analysis of the potential environmental consequences.

Based on review of public comments, coupled with the consultations held with commenting agencies as well as State and tribal governments, the main EIS enhancements include the following:

Seismic and water resources discussions were reviewed, clarified, and enhanced for all alternative sites, and current data and analyses were added to Volumes 1 and 2, as appropriate.

A discussion of potential accidents caused by a common initiator was added. The option of stabilizing some of DOE's SNF (specifically from the N Reactor) by processing it at available facilities located overseas was added, thus enhancing the processing options discussed in the EIS. An analysis of barge transportation was added to the EIS, with respect to the option of transporting N-Reactor fuel to a shipping point for overseas processing, as well as to support the potential transport of Brookhaven National Laboratory SNF to another site, as appropriate.

In addition, an analysis of shipboard fires was added, primarily in response to comments related to receiving SNF containing uranium of U.S. origin from foreign research reactors.

In Volume 2 of the EIS, the air quality analysis was revised to upgrade the existing baseline conditions and impacts of alternatives in terms of the amount of Prevention of Significant Deterioration (PSD) increment consumed, thus updating the baseline conditions presented for the Idaho National Engineering Laboratory. Additionally, the Waste Experimental Reduction Facility project summary was enhanced and clarified. This EIS was also revised to reflect current projections of employment, including the projected downsizing of the Idaho National Engineering Laboratory due to contractor consolidation.

In response to public comments, a brief summary of the results of a separate evaluation of the costs of the various alternatives was added to the EIS, although the cost evaluation was performed independently of the EIS for additional purposes. The discussion of the options regarding the management of Fort St. Vrain SNF currently stored in Colorado has been expanded. As committed to in the Draft EIS, the evaluation and discussion of environmental justice has been expanded in both Volumes 1 and 2 of the EIS. This analysis was based on interim DOE guidance in the absence of interagency policy in this regard and reflects limited public comments received regarding environmental justice. Consultation with the commenting Native American tribes is reflected in the environmental justice analysis, as well as in the various sections of the EIS, as appropriate.

Other enhancements include a clarification that potential shipment of SNF containing uranium of U.S. origin from foreign research reactors consists of a bounding estimate of 22 MTHM.

In addition, as a result of public comments, Volume 1 of the EIS was enhanced to clarify the relationship between current DOE National Environmental Policy Act actions and this EIS. Likewise, the relationship between the EIS and the Spent Fuel Vulnerability Action Plans was clarified in this EIS. With respect to the naval SNF, Appendix D of Volume 1 was modified to more fully explain the import of naval SNF and to discuss potential effects of terrorist attacks at naval shipyards.

2. PURPOSE AND NEED FOR AGENCY ACTION

DOE, according to the Atomic Energy Act of 1954, as amended, is responsible for developing and maintaining a capability to manage nuclear materials [Atomic Energy Act Sections 11(z), 11(aa), and 11(e)]. During the last four decades, DOE and its predecessor agencies have transported, received, stored, and reprocessed approximately 100,000 MTHM of SNF from various sources, including DOE production reactors; the Naval Nuclear Propulsion Program; DOE, university, and other research and test reactors; special case commercial power reactors; and certain foreign research reactors. Approximately 2,700 MTHM of SNF was not reprocessed and is stored at various locations in the United States and overseas. Approximately 100 MTHM of additional SNF is projected to be received in the next 40 years. This SNF is in a wide range of enrichments, types, and conditions.

The end of the Cold War led DOE to reevaluate the scale of its weapons production, nuclear propulsion, and research missions. In April 1992, the Secretary of Energy directed DOE to phase out reprocessing of SNF for recovery and recycling of plutonium and highly enriched uranium to support the nuclear weapons stockpile. In 1993, a DOE report[a] documented current and potential environmental, safety, and health vulnerabilities regarding existing DOE SNF storage facilities. The report identified locations with degraded fuel cladding integrity and other problems that require action to ensure continued safe storage. As a result of the Secretary's directive and the information in the DOE report, the proposed action is to safely, efficiently, and responsibly manage existing and projected quantities of spent nuclear fuel through the year 2035, pending ultimate disposition.

As part of establishing an effective SNF Management Program, DOE needs to make complex-wide strategic decisions for the management of SNF for the next 40 years, including (a) where to conduct SNF management activities, after evaluating existing and potential locations, (b) the appropriate capabilities, facilities, and technologies for SNF management, and (c) the research and development activities to support the SNF Management Program.

Volume 1 of this EIS focuses on strategies for where to conduct SNF management activities as in (a) above. Decisions on the site-specific and technical implementation of the program, as in (b) and (c) above, would be made after subsequent, tiered National Environmental Policy Act reviews, as appropriate.

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[a] Spent Fuel Working Group Report on Inventory and Storage of the Department's Spent Nuclear Fuel and Other Reactor Irradiated Nuclear Materials and Their Environmental, Safety and Health Vulnerabilities (DOE 1993b.)

3. ALTERNATIVES

Chapter 3 describes a range of programmatic alternatives for managing the DOE SNF currently stored within the DOE complex and at non-DOE generator sites. These alternatives also address SNF that is projected to be generated through the year 2035. Figure 1-2, given in Chapter 1, identifies locations within the United States where DOE SNF is being generated and stored.

The five alternatives analyzed in Volume 1 of this EIS are summarized in the box to the right. These alternatives, which are consistent with the alternatives under consideration for the DOE Waste Management Programmatic EIS, present a range of programmatic approaches for managing existing and projected SNF inventories. The alternatives involve varying amounts of SNF shipments, levels of fuel stabilization, numbers and types of storage facilities, and the scope of research and development efforts for SNF management technologies.

Summary of Alternatives for the Management of DOE Spent Nuclear Fuel

No Action

Take minimum actions required for safe and secure management of SNF at or close to the generation site or current storage location.

Decentralization

Store most SNF at or close to the generation site or current storage location, with limited shipments to DOE facilities.

1992/1993 Planning Basis

Transport and store newly generated SNF at the Idaho National Engineering Laboratory or Savannah River Site. Consolidate some existing fuels at the Idaho National Engineering Laboratory or at the Savannah River Site.

Regionalization

Distribute existing and projected SNF among DOE sites based primarily on fuel type (Regionalization 4A) or geographic location (Regionalization 4B).

Centralization

Manage all existing and projected SNF inventories at one site until ultimate disposition.

The programmatic action that DOE ultimately selects is not necessarily limited to one of the alternatives presented. A hybrid alternative could, for example, be developed that would incorporate actions from one or more of the five alternatives analyzed. Moreover, the programmatic decisions will not identify all site-specific SNF management options. If appropriate, the decisions would be made after additional site-specific National Environmental Policy Act evaluations.

In developing the alternatives, the need to comply with applicable regulations, permits, and DOE orders was assumed. Under some of the alternatives (for example, No Action and Decentralization), DOE would be required to renegotiate existing commitments to accept SNF from utilities (for example, Fort St. Vrain), domestic research reactor SNF, and potential agreements to accept foreign research reactor SNF.

Under all alternatives, actions to resolve outstanding SNF management deficiencies identified and prioritized according to the Defense Nuclear Facilities Safety Board Recommendation 94-1 Implementation Plan would be implemented as appropriate. The Defense Nuclear Facilities Safety Board 94-1 Implementation Plan will be balanced with other factors such as budgetary constraints and public comments. Under all alternatives, DOE would consider ways to reduce costs for the management of SNF.

Some of the alternatives include references to transition periods. These can be defined as the periods of time needed to fully implement the alternative, if selected. Transition periods vary from 3 to 20 years depending on the time required to plan, design, procure, or construct equipment and facilities needed to fully implement the alternative. Activities taking place during transition periods would be similar to anticipated activities associated with one or more of the defined alternatives. Therefore, environmental impacts of transition period activities are bounded by the impacts assessment for the defined alternatives.

The DOE SNF Management Program is intended to (a) provide interim storage and management for SNF at specified locations until ultimate disposition, (b) stabilize the fuel as required for environmentally safe storage and protection of human health (for both workers and the public), (c) increase safe storage capacity, replacing facilities that cannot meet current standards and provide additional capacity for newly generated SNF, (d) conduct research and development initiatives to support safe storage and safe disposal, and (e) examine SNF generated by the Naval Nuclear Propulsion Program. The possible need to convert SNF into a form that meets the acceptance criteria of geologic repositories is beyond the scope of this EIS and will be the subject of future National Environmental Policy Act review.

The planning period for this EIS is 40 years, beginning with the issuance of the Record of Decision (that is, baseline conditions in June 1995) and extending through the year 2035. The 40-year timeframe may be required to make and implement decisions on the ultimate disposition of SNF. Detailed impact analyses are performed for the time period from 1995 to 2005. Normal operation impacts are then projected for the remaining 30 years.

Decisions as a result of this EIS apply to actions taken by DOE and the Navy from the date of the Record of Decision through the interim storage period. At the present time, intersite shipments of DOE SNF have been curtailed. However, limited shipments of SNF from Navy shipyards have occurred during the preparation of the EIS. Shipments from sources such as universities and foreign research reactors needing urgent relief have also occurred. These shipments are in accordance with existing court orders, Federal facility compliance agreements, and Council on Environmental Quality regulations. If the No Action alternative is selected in the Record of Decision, all such shipments would cease after an appropriate transition period.

After considering a number of elements, DOE has identified Regionalization 4A (management by fuel type) as the preferred alternative. DOE arrived at its preferred alternative through a formal decision management process, which included developing screening and performance criteria. Screening criteria are requirements that an alternative must satisfy to be further evaluated; performance criteria are desirable attributes or characteristics that help distinguish the relative merit of each alternative that satisfies the screening criteria. After applying the screening criteria, additional management considerations (technical and nontechnical), discussed below, were used to arrive at the final preferred alternative.

The screening and performance criteria were developed considering the following factors: (a) environmental impact, (b) environmental regulatory compliance, (c) DOE and SNF programmatic missions, (d) public comments, (e) national security mission, (f) cost, and (g) DOE policy.

Each alternative was first evaluated based on the following screening criteria:

Resolving vulnerabilities consistent with DOE's Plan of Action to Resolve Spent Nuclear Fuel Vulnerabilities (DOE 1994a, b, c)

Complying with all applicable Federal and state environmental laws and regulations, consent orders, and Federal facility agreements

Maintaining backup capabilities for SNF management to limit interruptions of vital SNF program activities

Providing the capability for 100 percent examination of naval SNF

Providing technology development for SNF treatment, storage, and ultimate disposition.

Those alternatives that did not satisfy all of the screening criteria were not considered further, and these were No Action, Decentralization A and B, and Centralization. The remaining alternatives, 1992-93 Planning Basis, Decentralization C, and Regionalization 4A and 4B, met all of the screening criteria. These alternatives were then evaluated based on optimizing overall performance relative to the following performance criteria:

Minimizing transport of SNF

Minimizing environmental impact

Assuring lowest cost consistent with mission accomplishment

Maximizing support for DOE's National SNF Program to achieve safe storage and preparation for final disposition

Maximizing DOE's ability to honor new and historical commitments and contracts.

Applying these performance criteria, two of the four remaining alternatives, 1992-93 Planning Basis and Regionalization 4A, rated the highest, so they were determined to be candidates for the preferred alternative. These candidate alternatives were then evaluated against a number of technical and nontechnical considerations, including environmental impact perception, indicated stakeholder preferences, implementation factors, regulatory risk, SNF processing potential, environmental justice, and fairness. This final evaluation resulted in Regionalization 4A being identified as the preferred alternative, because Regionalization 4A better supports a path forward for ultimate disposition of the SNF. Additional information on this alternative can be found in Section 3.1.4.

While the Nevada Test Site is analyzed in this EIS as an alternative site for SNF management activities, DOE did not consider it to be a preferred site for the management of SNF because of the State of Nevada's current role as the host site for the Yucca Mountain Site Characterization Project and the Nevada Test Site's lack of SNF management facilities and high-level waste infrastructure.

The DOE's preferred alternative is consistent with the Navy's preferred alternative to continue to conduct refueling and defueling of nuclear-powered vessels and prototypes, and to transport SNF to the Idaho National Engineering Laboratory for full examination and interim storage, using the same practices as in the past. Details and analyses supporting the Navy's preferred alternative can be found in Appendix D of Volume 1.

The remainder of this chapter is comprised of three sections. Section 3.1 summarizes the alternatives and the implications for each site. Section 3.2 discusses the alternatives eliminated from further evaluation. Section 3.3 provides a brief comparison of the potential environmental impacts associated with each alternative.

3.1 Overview of Alternatives Considered

Section 3.1 and Tables 3-1 through 3-5 discuss the potential actions at each site as a result of implementing each of the alternatives.

Table 3-1. Summary of the No Action alternativeTable 3-2. Summary of the Decentralization alternative.Table 3-3. Summary of the 1992/1993 Planning Basis alternativeTable 3-4. Summary of the Regionalization alternative.Table 3-4. Summary of the Regionalization alternative (cont.).Table 3-5. Summary of the Centralization alternative.Table 3-5. Summary of the Centralization alterantive (cont.).

No Action Alternative

Take minimum actions required for safe and secure management of SNF at or close to the generation site or current storage location.

After an approximate 3-year transition period, no transport of SNF to or from DOE facilities would occur.

Stabilization activities would be limited to the minimum actions required to safely store SNF.
Naval reactor SNF would be stored at naval sites.
Facility upgrade/replacement and onsite fuel transfers would be limited to those necessary for safe interim storage.
Existing research and development activities would continue.

3.1.1 No Action

The No Action alternative is an alternative required under the Council on Environmental Quality regulations for implementing the National Environmental Policy Act of 1969. Under the No Action alternative, DOE would limit actions to the minimum necessary for safe and secure management of SNF at the generation site or current storage location. Under this alternative, small and large DOE sites, naval sites, university and other non-DOE domestic reactors, and foreign research reactors would all independently manage their SNF onsite. Generally, after an appropriate transition period SNF shipments between sites for management purposes would be discontinued, including those SNF shipments currently allowed by court orders and Federal facility compliance agreements. Figure 3-1 indicates SNF inventories. The technology development activities related to SNF management, limited to activities already approved, would continue within DOE. Figure 3-1 also shows the distribution of fuel from 1995 through 2035.

The following subsections highlight actions associated with the No Action alternative at the sites being considered for SNF management.

3.1.1.1 Hanford Site.

Under the No Action alternative at the Hanford Site, only those actions deemed necessary for the continued safe and secure management of the SNF would be carried out. Thus, the existing SNF would be maintained close to its current storage locations and there would be minimal facility upgrades. Activities required to safely store SNF would continue.

Specific actions proposed for the near term include proceeding with the characterization of defense production reactor fuel to establish safe interim storage limits, containerizing the fuel in the 105-KE reactor basin by 1998, procuring the first 10 dry storage casks for the Fast Flux Test Facility, transferring SNF to dry cask storage if required for safety reasons (with emphasis on Fast Flux Test Facility fuel now stored in liquid sodium), and possibly consolidating SNF from defense production at the 105-KW reactor basin.

Figure 3-1. Spent nuclear fuel distribution, location, and inventory for the No Action alternative.

No new facilities are planned under the No Action alternative.

3.1.1.2 Idaho National Engineering Laboratory.

For the No Action alternative, DOE would maintain SNF close to defueling or current storage locations with minimal facility upgrades or replacements. The Idaho National Engineering Laboratory would neither receive nor transport SNF except for naval SNF during a transition period of about 3 years (see Section 3.1.1.6). After the transition period, naval SNF would not be transferred to the Idaho National Engineering Laboratory, and the Expended Core Facility at the Idaho

National Engineering Laboratory would be shut down. DOE would continue to transfer onsite SNF to the Idaho Chemical Processing Plant until the existing storage capacity is used.

DOE would continue operating existing SNF-related facilities at the Idaho National Engineering Laboratory. Because of the deteriorated condition of some of the fuel stored underwater in the CPP-603 Underwater Fuel Storage Facility, additional characterization and canning capabilities would be necessary to stabilize the fuel for safe transport and subsequent storage. DOE has scheduled the installation and operation of new fuel characterization and canning equipment in the Irradiated Fuel Storage Facility by late 1995 to provide these capabilities. DOE would perform other required stabilization of SNF at the Idaho National Engineering Laboratory in either the Remote Analytical Laboratory or the Fluorinel Dissolution Process Hot Cell. DOE would not start any new projects to increase SNF interim storage capacity.

SNF research and development would be limited. Existing SNF management research and development projects would continue, but the development of technology for the ultimate disposition of SNF would cease. Existing facilities, such as the Process Improvement Facility, the Remote Analytical Laboratory, and the Pilot Plant Facility, would support continuing research and development work.

3.1.1.3 Savannah River Site.

For the No Action alternative, DOE would use the existing Savannah River Site facilities for extended wet storage of its current SNF inventories. The Savannah River Site would not transport any SNF offsite and would not receive any SNF. Only onsite consolidation and rearrangement would take place. DOE would temporarily move fuel currently on the Savannah River Site among facilities to accommodate facility upgrades.

Six Savannah River Site facilities are used for the storage of SNF: the Receiving Basin for Offsite Fuel, K-Reactor Disassembly Basin, L-Reactor Disassembly Basin, P-Reactor Disassembly Basin, F-Canyon, and H-Canyon. Most of the fuel is located in the Receiving Basin for Offsite Fuel, the L-Reactor Disassembly Basin, and the F-Canyon. DOE would accomplish onsite transfers as required to ensure the safety of aluminum-clad fuel. The Receiving Basin for Offsite Fuels and an upgraded reactor basin would be utilized for continued storage of this fuel. Additionally, DOE would place the aluminum-clad fuel, which is degrading because of corrosion, in containers to minimize the spread of radioactive material in the pools in case the cladding is breached. DOE would continue existing SNF-related research and development.

3.1.1.4 Oak Ridge Reservation.

Under the No Action alternative, the Oak Ridge National Laboratory, which is on the Oak Ridge Reservation, would generate and store SNF as a result of reactor research activities. No SNF would be transported to the Oak Ridge Reservation, and no SNF would be transported offsite. SNF would be stabilized, as necessary, to ensure safe storage. Oak Ridge Reservation research and development activities would continue as planned except that the alternative could lead to the shutdown of the High Flux Isotope Reactor as a result of filling the existing SNF storage capacity. Additional SNF management planning is not expected to be required for the Bulk Shielding Reactor or the Oak Ridge Research Reactor through the year 2035. It is anticipated that the fuel now stored in the Tower Shielding Reactor No. II core would be moved to the Y-12 area at the Oak Ridge Reservation for interim storage. If this is not possible, additional storage space or cessation of reactor operations may be required after 2005. If the Advanced Neutron Source becomes operational in 2005, additional SNF interim storage space may be required.

3.1.1.5 Nevada Test Site.

The Nevada Test Site does not generate or store any SNF and would not receive any SNF under the No Action alternative. Therefore, this alternative does not affect the Nevada Test Site.

3.1.1.6 Naval Nuclear Propulsion Program.

Under the No Action alternative, naval reactors would continue to be defueled and refueled as planned. In accordance with normal practices, the spent fuel would be removed from the ships (or prototypes) and placed into shipping containers. No action would be needed to prepare the naval SNF for storage because of its corrosion resistance, high integrity, and strength. The SNF would be stored in this condition at a location near the defueling site. Naval SNF from ships defueled or refueled at Newport News Shipbuilding, a private shipyard located in Newport News, Virginia, would be transported to the Norfolk Naval Shipyard, in Portsmouth, Virginia, which is the nearest naval site.

Under this alternative, examination of naval SNF would ultimately cease. A transition period of approximately 3 years would be required to procure sufficient shipping containers to store naval SNF being removed by ongoing defueling or refueling. During this period, naval SNF would continue to be transported to the Idaho National Engineering Laboratory for detailed examination and storage. After the transition period, naval SNF would no longer be transported to the Idaho National Engineering Laboratory for examination and subsequent storage; the SNF removed from naval reactors would remain for storage at the naval sites. In addition, the Expended Core Facility at the Idaho National Engineering Laboratory would be shut down.

3.1.1.7 Other Generator/Storage Locations.

Under the No Action alternative, the SNF generated and/or stored at DOE research and non-DOE research reactors and other locations would not be transported offsite. For the purposes of this analysis, it is assumed that SNF from foreign research reactors would not be transported to the United States under this alternative. DOE research reactors with adequate storage capacity could continue operating as planned. If the onsite storage capacity is inadequate or cannot be expanded, new plans would have to be considered, including potential cessation of reactor operations after storage capacity limits are reached.

The No Action alternative would also affect the management of SNF from nuclear power plants that DOE is obligated to store. For this alternative, the SNF would remain at these sites. Stabilization would be performed, as necessary, to ensure safe storage. Loss of access to the Idaho National Engineering Laboratory for storage of its SNF has already resulted in the construction of new onsite SNF storage at Fort St. Vrain. Therefore, implementation of the No Action alternative would have no additional impact on the management of SNF at Fort St. Vrain.

3.1.2 Decentralization

Decentralization Alternative
Store most SNF at or close to the generation site or current storage location, with limited shipments to DOE facilities.

DOE SNF shipments would be limited to the following:
- SNF stored or generated at universities and non-DOE facilities
- Potential foreign research reactor fuel.

SNF processing might need to be conducted. Other forms of stabilization might occur to provide for safe storage and/or transport.
Some facilities would be upgraded/replaced and additional storage capacity required by the alternative would be constructed.
Onsite fuel transfers would occur for improved safe storage.

Research and development activities would be undertaken for SNF management, including stabilization technology.
Three options for naval fuel
- No inspection fuel remains close to refueling/defueling site
- Limited inspection at Puget Sound Naval Shipyard
- Full inspection at the Idaho National Engineering Laboratory followed by storage close to refueling/defueling site.

Under the Decentralization alternative, DOE would (a) maintain existing SNF in storage at current locations, and (b) store new SNF at or near the site of generation, thereby reducing the amount of fuel transported before a decision on ultimate disposition. This alternative differs from the No Action alternative by slightly increasing shipments to DOE sites and developing or upgrading facilities. Table 3-2 summarizes the basic actions at each site under this alternative. Actions that would improve management of SNF would be undertaken. SNF processing and research and development would be performed. Fuel may be transported for safety or research and development purposes. Figure 3-2 identifies the movement of fuel from 1995 through 2035 under this alternative. SNF from non-DOE locations would be transported to one of the major existing sites for management. SNF managed by DOE would remain at its current location until a decision on final disposition is made. The Navy has evaluated three options for SNF management under this alternative, based on the amount of examination that would be performed on the SNF. In general, naval SNF would be stored at the defueling site. SNF from Newport News Shipbuilding would be transferred to the Norfolk Naval Shipyard.

3.1.2.1 Hanford Site.

Under the Decentralization alternative, the near-term activities at the Hanford Site include those activities identified under the No Action alternative, as well as substantial facility development and upgrades, and SNF processing research and development. In addition to the three principal activities identified for the No Action alternative (that is, fuel characterization, fuel canning, and cask procurement for Fast Flux Test Facility fuel), the following general activities would also occur: evaluating wet and dry storage methods for defense production N-Reactor and Single-Pass Reactor fuel; evaluating dry storage methods for other fuels (Shippingport Core II, Fast Flux Test Facility, miscellaneous); conducting extensive research and development on defense production SNF stabilization techniques; and constructing and using wet and/or dry storage facilities and possibly a stabilization facility. In response to public comment, this alternative also includes the option to process defense production SNF at an overseas facility. A discussion of this option is provided in Volume 1, Appendix A, Attachment B.

Figure 3-2. Spent nuclear fuel distribution, location, and inventory for the Decentralization alternative.

The Hanford Site would not transport SNF to or receive SNF from offsite locations, unless the option to process defense production SNF at an overseas facility is selected. Local transport of fuel would occur to support safety requirements, improved SNF management, and research and development activities.

Combinations of wet and dry storage would be considered. Either a new wet storage facility or dry casks or vault-type dry storage would be needed to replace existing facilities. Dry storage of defense production SNF would require a new stabilization facility. Because of substantial chemical and physical differences between defense production fuels and the nondefense fuels, it is possible that separate storage facilities would be built. Additional National Environmental Policy Act documentation would be prepared before selecting this option.

3.1.2.2 Idaho National Engineering Laboratory.

Under the Decentralization alternative, the Idaho National Engineering Laboratory would accept limited shipments of SNF for storage, including SNF from some domestic research reactors and some foreign research reactors. Some onsite transfers would also be conducted. DOE would manage the existing SNF at the Idaho National Engineering Laboratory, such as the naval SNF at the Naval Reactors Facility and the SNF in underwater pools, to accomplish safe and secure interim storage until ultimate disposition.

DOE would use the characterization and canning equipment described for the No Action alternative to stabilize SNF removed from the CPP-603 Underwater Fuel Storage Facility for interim SNF storage. DOE would transfer the SNF in the CPP-603 Underwater Fuel Storage Facility to the Fuel Storage Area by the year 2000. DOE would continue to use the Underground Storage Facility and the Irradiated Fuel Storage Facility for existing SNF inventory and transfers of other SNF based on safety analyses. DOE would upgrade or increase fuel storage capacity at the Idaho National Engineering Laboratory, as required.

The Idaho National Engineering Laboratory would conduct various research and development activities, including laboratory and pilot-plant testing, continued repository performance assessments and acceptance criteria development, and the characterization of SNF.

The Idaho National Engineering Laboratory would examine different amounts of naval SNF, depending on the option selected for the Navy Nuclear Propulsion Program (see Section 3.1.2.6). Under two of the three options, the Expended Core Facility would ultimately be shut down. As with the No Action alternative, each of the options for naval fuel would require a transition period. During this transition period, SNF would be transported in shipping containers to the Expended Core Facility for examination and then to the Idaho Chemical Processing Plant for storage.

3.1.2.3 Savannah River Site.

The near-term fuel transfer and consolidation activities at the Savannah River Site for the Decentralization alternative would be similar to those under the No Action alternative, except that the site would receive limited SNF shipments from other locations. The Savannah River Site would receive research and test reactor fuel from some domestic and perhaps some foreign research reactors. This SNF would consist primarily of aluminum-clad fuel elements and some stainless steel and zircaloy fuel elements.

Fuel would continue to be stored in the Receiving Basin for Offsite Fuels and in an upgraded reactor basin until it is either canned, placed in wet or dry storage, or is processed. The processing option represented for evaluation in the EIS consists of processing existing Savannah River Site aluminum-clad fuel using existing chemical separations facilities (that is, F- and H-Canyons) and storing the current inventory of stainless-steel-clad and zirconium-clad fuel as well as future receipts of aluminum-clad SNF.

This option is analyzed because DOE has data from past processing that can be used for analyses. The impacts from this technology are representative of other processing technology options that may be considered in the future. Other processing options, such as processing all SNF or processing coupled with vitrification, are also feasible and would be analyzed as part of the site-specific National Environmental Policy Act documentation needed to implement any option for this alternative.

The Decentralization alternative would require a new fuel characterization facility, a new wet or dry canning facility, and a new wet or dry storage facility. The Savannah River Site would evaluate wet and dry storage and processing options because (as in the No Action alternative) interim wet storage of the fuel elements without canning could cause corrosion and cladding failures. The Savannah River Site would initiate projects to design characterization, canning, and dry storage facilities for aluminum-clad fuels. Ongoing SNF research would continue at the site.

3.1.2.4 Oak Ridge Reservation.

Under the Decentralization alternative, the Oak Ridge National Laboratory would generate and store SNF from reactor research activities. No SNF would be transported to the Oak Ridge Reservation except for small amounts associated with research and development activities (for example, from Sandia National Laboratories). No SNF would be transported offsite. SNF would be stabilized, as necessary, to provide safe storage. Research and development activities at the Oak Ridge Reservation would continue as planned. Because the interim storage capacity for SNF at the Oak Ridge Reservation is limited, new interim storage capacity would be added. The amount of SNF in interim storage would not increase substantially.

3.1.2.5 Nevada Test Site.

Under the Decentralization alternative, the Nevada Test Site would not generate or store any SNF and would not receive any SNF. Therefore, this alternative is not applicable to the Nevada Test Site.

3.1.2.6 Naval Nuclear Propulsion Program.

The Decentralization alternative at the naval sites is similar to the No Action alternative because naval reactors would continue to be defueled and refueled as planned, and the fuel would generally be stored at or near the defueling site. No action would be needed to prepare the naval SNF for storage because of its corrosion resistance, high integrity, and strength. A transition period would be required while the necessary interim storage capabilities could be procured and developed at the naval sites. During this period, naval SNF would continue to be transported to the Expended Core Facility for examination and subsequent interim storage at the Idaho National Engineering Laboratory. The principal difference from the No Action alternative is that the options for interim storage would be selected from shipping containers, dry storage casks, and wet storage in water pools. Another important difference is that examination of naval fuel would be possible.

Under this alternative, the Navy has three options, which vary by the amount of detailed examination that could be performed on the naval SNF:

Option A, No Examination-Interim storage of naval SNF at the naval site of origin without any detailed examination, except during the 3-year transition period when naval SNF would continue to be transported to the Expended Core Facility at the Idaho National Engineering Laboratory for detailed examination and preparation for storage at the Idaho Chemical Processing Plant.

Option B, Limited Examination-Transport approximately 10 percent of the naval SNF to the Puget Sound Naval Shipyard where the existing water pool, designed to support aircraft carrier refuelings, would be modified to enable limited examination of certain high-priority SNF. Use of this water pool for examination would preclude the performance of aircraft carrier refueling work at the shipyard.

Option C, Full Examination-Transport naval SNF to the Expended Core Facility for full examination and then return the fuel to the naval or DOE facility near the site of origin for storage.

For Option A, the Expended Core Facility at the Idaho National Engineering Laboratory would be shut down after the transition period. For Option B, the water pool facility at the Puget Sound Naval Shipyard would be modified to support SNF examinations and, upon completion, the Expended Core Facility would be shut down. It would not be possible to perform aircraft carrier refuelings at the Puget Sound Naval Shipyard if this option were selected. Under Options A and B, examinations of SNF would be either terminated or severely decreased. Under Option C, the Expended Core Facility would continue to operate, and planned Expended Core Facility improvements, including construction of the dry cell, would be completed.

3.1.2.7 Other Generator/Storage Locations.

The Decentralization alternative for other generators and storage locations is similar to the No Action alternative because offsite transport of SNF would be allowed in limited amounts for continued operation. Thus, both DOE and non-DOE research reactors would be allowed to transport SNF offsite, as necessary. Additional SNF interim storage facilities at domestic research reactors would not be required. For this alternative, SNF currently stored at the West Valley Demonstration Project, Babcock & Wilcox Research Center, and the Fort St. Vrain power plant would remain at these sites. As identified in the No Action alternative, loss of access to the Idaho National Engineering Laboratory for storage of its SNF has already resulted in the construction of new onsite SNF storage at Fort St. Vrain. Therefore, implementation of the Decentralization alternative would have no additional impact on the management of SNF at Fort St. Vrain.

3.1.3 1992/1993 Planning Basis

1992/1993 Planning Basis Alternative

Transport to and store newly generated SNF at the Idaho National Engineering Laboratory or Savannah River Site. Consolidate some existing fuels at the Idaho National Engineering Laboratory or the Savannah River Site.

Fuel would be transported as follows:

- TRIGA fuel from the Hanford Site to the Idaho National Engineering Laboratory; Hanford Site receives limited fuel for research of storage and dispositioning technologies
- Naval fuel to the Idaho National Engineering Laboratory for examination and storage
- West Valley Demonstration Project and Fort St. Vrain fuel to the Idaho National Engineering Laboratory
- Oak Ridge Reservation fuel to the Savannah River Site
- Domestic research fuel, and foreign research reactor fuel as may yet be determined, divided between the Savannah River

Site and the Idaho National Engineering Laboratory.

Facilities upgrades and replacements that were planned would proceed, including increased storage capacity.
Research and development for SNF management would be undertaken, including stabilization technology.
SNF processing might need to be conducted. Other forms of stabilization might occur to provide for safe storage and/or transport.

The 1992/1993 Planning Basis alternative represents DOE's 1992/1993 plans for management of its SNF. Under this alternative, existing SNF located at major DOE sites would remain at those sites. This results in less intersite transportation of SNF compared with the other alternatives, except for the No Action alternative. Table 3-3 summarizes the basic actions at each site under this alternative.

Under this alternative, DOE would transport and store newly generated SNF at the Idaho National Engineering Laboratory or Savannah River Site. Some existing SNF currently at other sites would be consolidated at the Idaho National Engineering Laboratory or the Savannah River Site. Specifically, the Idaho National Engineering Laboratory would receive TRIGA fuel from the Hanford Site, SNF from naval sites, some test reactor SNF, SNF from the West Valley Demonstration Project and Fort St. Vrain, and some SNF from university and perhaps from foreign research reactors. The Savannah River Site would also receive some test reactor SNF and some SNF from university and perhaps from foreign research reactors. DOE sites would generally upgrade facilities and construct new facilities for the management of SNF.

Continued SNF transportation, receipt, processing, and storage are assumed for this alternative. The construction and operation of any new facilities required to accommodate current and project-specific SNF interim storage requirements would be implemented. Figure 3-3 identifies the movement of fuel from 1995 through 2035 under this alternative. Activities related to SNF processing would include research and development and pilot programs to support future decisions on the ultimate disposition of SNF.

Figure 3-3. Spent nuclear fuel distribution, location, and inventory for the 1992/1993 Planning Basis alternative.

Naval SNF would continue to be transported to the Expended Core Facility at the Idaho National Engineering Laboratory for examination. After examination, the SNF would be transferred to the Idaho Chemical Processing Plant for interim storage, pending ultimate disposition.

3.1.3.1 Hanford Site.

The activities at the Hanford Site for the 1992/1993 Planning Basis alternative are the same as those identified for the Decentralization alternative, except that 191 TRIGA SNF elements currently stored in the 308 Building and the 200 Area low-level burial grounds would be transported to the Idaho National Engineering Laboratory. No new SNF would be transported to the Hanford Site except for limited quantities of materials for research in support of interim storage technologies for ultimate disposition. Thus, the overall inventory at the Hanford Site would decrease slightly.

3.1.3.2 Idaho National Engineering Laboratory.

Under the 1992/1993 Planning Basis alternative, DOE would continue the maintenance and operation of existing SNF-related facilities in a manner similar to the No Action alternative; however, some consolidation of Idaho National Engineering Laboratory facilities could occur. Newly generated SNF would, with minor exceptions, be transported to either the Idaho National Engineering Laboratory or the Savannah River Site.

DOE would complete a new characterization and canning facility with appropriate inspection, conditioning, and packaging equipment to stabilize any new receipts of SNF and to prepare fuel currently in underwater storage for dry storage. DOE would upgrade or increase dry fuel storage capacity at the Idaho National Engineering Laboratory, as required.

SNF research and development, with the construction of a Technology Development Facility, would continue as planned. The Electrometallurgical Process Demonstration Project would continue at the Argonne National Laboratory-West Fuel Cycle Facility. The Dry Fuels Storage Facility would be used to demonstrate technology for the dry storage of selected DOE highly enriched uranium fuels.

Naval SNF would continue to be transported to the Expended Core Facility at the Idaho National Engineering Laboratory for examination. After examination, the SNF would be transferred to the Idaho Chemical Processing Plant for interim storage, pending ultimate disposition.

3.1.3.3 Savannah River Site.

The implementation of the 1992/1993 Planning Basis alternative at the Savannah River Site would involve the same actions and options as the Decentralization alternative, except that DOE would transfer about half of the newly generated domestic and foreign aluminum-clad research reactor SNF to the Savannah River Site.

The stabilization activities and options would be the same as those for the Decentralization alternative. The Savannah River Site would place the nonaluminum fuels and offsite aluminum-clad fuel receipts in interim storage and either process the aluminum-clad fuels currently at the Savannah River Site or place them in interim storage. The storage options and new facility requirements would also be the same as those for the Decentralization alternative. The Savannah River Site would undertake the same types of research and development programs as those described for the Decentralization alternative. Current ongoing activities would continue. The Savannah River Site would also conduct research and pilot-scale studies to determine the best technology for ultimate disposition of the aluminum-clad fuels.

3.1.3.4 Oak Ridge Reservation.

Under the 1992/1993 Planning Basis alternative, the Oak Ridge Reservation would transport excess SNF to other DOE locations as necessary to permit continued operations of Oak Ridge reactors. The option for acquiring dry storage facilities would support continued High Flux Isotope Reactor operation during the transition period. The amount of SNF stored at the Oak Ridge Reservation would not increase. Research and development activities would continue, and SNF interim storage capacity would not increase.

3.1.3.5 Nevada Test Site.

Under the 1992/1993 Planning Basis alternative, the Nevada Test Site would not generate or store any SNF and would not receive any SNF. Therefore, this alternative is not applicable to the Nevada Test Site.

3.1.3.6 Naval Nuclear Propulsion Program.

Under this alternative, naval reactors would continue to be defueled and refueled as planned. Upon removal from the ship, the SNF would be transported to the Expended Core Facility at the Idaho National Engineering Laboratory for examination. After examination, the fuel would be transported to the Idaho Chemical Processing Plant for interim storage, pending ultimate disposition. No action to prepare the SNF for storage would be necessary because of its corrosion resistance, high integrity, and strength. Planned improvements for the Expended Core Facility, including construction of the dry cell facility, would be completed.

3.1.3.7 Other Generator/Storage Locations.

Under this alternative, SNF would continue to be transported to designated DOE sites. At Brookhaven National Laboratory, implementation of this alternative could require a transition period of several years and construction of temporary SNF storage facilities or acquisition of dry storage containers. DOE assumes that no additional SNF interim storage facilities would be constructed at the other generator/storage sites. For this alternative, SNF currently stored at the West Valley Demonstration Project, Babcock & Wilcox Research Center, and the Fort St. Vrain power plant would be transported to the Idaho National Engineering Laboratory.

3.1.4 Regionalization

The Regionalization alternative comprises Regionalization 4A, which would assign existing and projected SNF among DOE sites based primarily on fuel type, and Regionalization 4B, which would assign fuels geographically. This subsection briefly defines each one, provides a boxed summary, and discusses the implications of both on each site.

Table 3-4 summarizes actions at the sites being considered for the Regionalization alternative.

Regionalization 4A Preferred Alternative

Distribute existing and projected SNF among DOE sites based primarily on fuel type.

Naval fuel would be transported to, examined, and stored at the Idaho National Engineering Laboratory.

Aluminum-clad fuel would be transported to the Savannah River Site; TRIGA and nonaluminum fuel would be transported to the Idaho National Engineering Laboratory; defense production fuel would be retained at the Hanford Site.

SNF processing might need to be conducted. Other forms of stabilization might occur to provide for safe storage and/or transport.

Facilities required to support SNF management would be upgraded or built as necessary.

Research and development for SNF management would be undertaken, including stabilization technology.

Regionalization 4A is the management of SNF based on the specific fuel type. The DOE has identified Regionalization 4A as its preferred alternative (see Section 3.0). All SNF would be transported to and stored at either the Idaho National Engineering Laboratory or the Savannah River Site, depending upon the fuel type, with the exception of defense production fuel that would be retained at the Hanford Site. Regionalization 4A is similar to the 1992/1993 Planning Basis alternative but involves more intersite transportation of SNF to the sites, depending on the existing capabilities of the sites to manage the specific fuel types with respect to cladding material, physical and chemical composition, fuel condition, and adequate facilities to handle the increased quantity. Actions for this alternative would assign all but defense production SNF to either the Idaho National Engineering Laboratory or the Savannah River Site, depending on the fuel type.

Figure 3-4 shows the movement of SNF from 1995 through 2035 under Regionalization 4A. Facility upgrades, replacements, and additions would be undertaken to the extent required by this alternative. Activities related to the management of SNF, including research and development activities, would be included.

Figure 3-4. Spent nuclear fuel distribution, location, and inventory for Regionalization 4A (by fuel type).

Regionalization 4B

Distribute existing and projected SNF between an Eastern Regional Site (either Oak Ridge Reservation or Savannah River Site) and a Western Regional Site (either Hanford Site, Idaho National Engineering Laboratory, or Nevada Test Site).

The Eastern Regional Site would receive fuel from east of the Mississippi River and the Western Regional Site would receive fuel from west of the Mississippi River.

Naval fuel would be transported to, examined, and stored at either the Western Regional Site or the Eastern Regional Site.

SNF processing might need to be conducted. Other forms of stabilization might occur to provide for safe storage and/or transport.

Facilities required to support SNF management would be upgraded or built as necessary.

Research and development would be undertaken for SNF management, including stabilization technology.

Regionalization 4B is the management of SNF based on geography. In general, SNF from eastern locations (east of the Mississippi River) would be consolidated at the Eastern Regional Site (either the Oak Ridge Reservation or the Savannah River Site); SNF from western locations (west of the Mississippi River) would be consolidated at the Western Regional Site (either the Hanford Site, the Idaho National Engineering Laboratory, or the Nevada Test Site). All naval SNF would be transported to, examined, and stored at either the Eastern or the Western Regional Site. Regionalization 4B has 10 options, based on the combination of sites selected as the Eastern and Western Regional Site and the placement of the expended core facility at either the Eastern or the Western Regional Site. There are three potential Western and two potential Eastern Regional Sites that could be paired, with either supporting the expended core facility. Neither of the two possible combinations that include the Idaho National Engineering Laboratory as the Western Regional Site would consider constructing another expended core facility at the Eastern Site because of the estimated $1 billion cost to construct the expended core facility. Figure 3-5 shows the movement of SNF from 1995 through 2035 under Regionalization 4B with the Idaho National Engineering Laboratory as the Western Regional Site and the Savannah River Site as the Eastern Regional Site. Facility upgrades, replacements, and additions would be undertaken to the extent required by Regionalization 4B. Activities related to the management of

SNF, including research and development, would be included.

3.1.4.1 Hanford Site.

Regionalization 4A-Under Regionalization 4A, activities at the Hanford Site would be intermediate to those of the Decentralization and the 1992/1993 Planning Basis alternatives. Hanford would continue to store its defense production fuel. The Hanford Site would not receive any shipments of SNF and would transport commercial remnants and stainless steel and nondefense production zircaloy-clad fuels to the Idaho National Engineering Laboratory. Facility upgrades, replacements, and additions associated with defense production fuel would occur as for the Decentralization and 1992/1993 Planning Basis alternatives. Minor facility additions required to consolidate and prepare other onsite SNF for transport offsite would also occur.

Figure 3-5. Spent nuclear fuel distribution, location, and inventory for Regionalization 4B (by geography).

Regionalization 4B-If the Hanford Site were selected as the Western Regional Site for implementation of Regionalization 4B, DOE SNF located or generated in the western United States and possibly naval SNF nationwide would be sent to the Hanford Site. This would require the completion of upgrades, increases, and replacements of storage capacity identified for the existing inventory under the Decentralization alternative, as well as additional capacity to accommodate DOE SNF and naval SNF within the existing or new facilities. A new stabilization facility may be required to accomplish safe interim storage of SNF.

New facilities would also be required to receive, handle, and store offsite fuel. In addition, a new facility for research and development and pilot programs would be required to support ultimate disposition. An expended core facility would be built on the Hanford Site, if the naval SNF were sent to the Hanford Site.

Implementation of Regionalization 4B at a site other than the Hanford Site would require the Hanford Site to consolidate and prepare onsite SNF for transport to the Western Regional Site. Because of the potential chemical reactivity of the defense production fuel at Hanford, it would require stabilization before offsite transport, which would require a new facility similar to the one described in the Decentralization alternative. Additional casks and associated handling equipment compatible with the receiving capabilities at the regional site may also be required. After the SNF is transported, related facilities at the Hanford Site would be closed.

3.1.4.2 Idaho National Engineering Laboratory.

Regionalization 4A-Under Regionalization A, stainless-steel- and zircaloy-clad, TRIGA, and naval SNF would be transported to the Idaho National Engineering Laboratory. The Idaho National Engineering Laboratory would transport aluminum-clad fuel to the Savannah River Site. Dry interim storage capacity would be increased and facility upgrades similar to those described for the 1992/1993 Planning Basis alternative would be undertaken, with replacements and additions as appropriate.

Regionalization 4B-If the Idaho National Engineering Laboratory were selected as the Western Regional Site for implementation of Regionalization 4B, SNF from western locations would be transported to the Idaho National Engineering Laboratory. The western facilities would characterize, stabilize, and can the SNF in containers compatible with dry storage at the Idaho Chemical Processing Plant at the Idaho National Engineering Laboratory. Naval SNF removed from naval reactors would be transported to the Expended Core Facility at the Idaho National Engineering Laboratory for examination. Following examination, the SNF would be transferred to the Idaho Chemical Processing Plant for interim storage.

DOE would complete an expanded Dry Fuels Storage Facility, which would include a new characterization and canning facility similar to the one described for the 1992/1993 Planning Basis alternative. In addition, the same new facility projects described for the 1992/1993 Planning Basis alternative would be initiated.

DOE would conduct SNF research and development. Similar to the 1992/1993 Planning Basis alternative, the Electrometallurgical Process Demonstration Project would continue at Argonne National Laboratory-West.

If implementation of Regionalization 4B were to occur at a different site, DOE would construct a characterization and canning facility at the Idaho Chemical Processing Plant to assist in stabilizing the different types of Idaho National Engineering Laboratory SNF before placement in various shipping casks and storage containers before transport to the selected Western Regional Site.

Similar to the No Action alternative, DOE would complete the transfer of the CPP-603 Underwater Fuel Storage Facility pool inventory to existing dry storage facilities by the year 2000. DOE would not build the Dry Fuels Storage Facility. DOE would then close all SNF-related facilities at the Idaho National Engineering Laboratory, except for operating reactor support facilities, such as the Advanced Test Reactor canal or the Argonne National Laboratory-West Hot Fuel Examination Facility and Fuel Cycle Facility.

The SNF-related research and development activities would be phased out, although the Electrometallurgical Process Demonstration Project would continue at Argonne National Laboratory-West (but would only test processes for SNF currently on the site). Similar to the No Action alternative, shipments of naval SNF to the Idaho National Engineering Laboratory would cease, and the Expended Core Facility would be phased out.

3.1.4.3 Savannah River Site.

Regionalization 4A-Under Regionalization 4A, DOE would transport aluminum-clad fuels to the Savannah River Site. The same actions and options as the Decentralization alternative would be required. The Savannah River Site would transport nonaluminum-clad fuels to the Idaho National Engineering Laboratory.

The stabilization activities and options would be similar to those described for the Decentralization alternative. The principal differences are that, under this alternative, the Savannah River Site would can and store more aluminum-clad fuel and would not manage nonaluminum-clad fuels. The amount of fuel processed would remain the same. The storage options and new facility requirements would be similar to those described for the Decentralization alternative, except that storage space for stainless-steel-clad and zirconium-alloy-clad fuels would not be necessary. The Savannah River Site would undertake similar types of research and development programs as those described for the 1992/1993 Planning Basis alternative. The principal difference would be that nonaluminum-clad fuels would not be included under this alternative.

Regionalization 4B-If the Savannah River Site were selected as the Eastern Regional Site for implementation of Regionalization 4B, eastern locations would transport aluminum-clad and nonaluminum-clad fuels to the site. In addition, naval SNF might be transported to the Savannah River Site, if the Eastern Regional Site were selected for naval fuels. The stabilization activities and options required would be similar to those for the Decentralization alternative. The Savannah River Site would store the nonaluminum fuels and either store or process the aluminum-clad fuels. The storage options and new facility requirements would also be the same as those for the Decentralization alternative. The Savannah River Site would undertake the same types of research and development programs as those described for the Decentralization alternative. Current ongoing activities would continue. The Savannah River Site would also conduct research and pilot-scale studies to determine the best technology for ultimate disposition of aluminum-clad fuels.

If the Savannah River Site were not selected as the Eastern Regional Site, DOE would transport SNF to the Oak Ridge Reservation. Some fuel would have to be stabilized before transport.

3.1.4.4 Oak Ridge Reservation.

Regionalization 4A-Under Regionalization 4A , the Oak Ridge Reservation would not receive SNF and would transport its aluminum-clad SNF to the Savannah River Site. All other SNF would be transported to the Idaho National Engineering Laboratory.

Regionalization 4B-If the Oak Ridge Reservation were selected as the Eastern Regional Site for implementation of Regionalization 4B, the eastern locations would transport SNF to the Oak Ridge Reservation for storage. In addition, naval SNF might be transported to the Oak Ridge Reservation if the Eastern Regional Site were selected for naval fuel. SNF currently stored at other DOE facilities would arrive at the Oak Ridge Reservation fully stabilized. New non-DOE domestic, foreign research reactor, and naval SNF would arrive in a condition necessary for safe transportation but uncanned. This fuel would be stabilized, prepared, and canned at the Oak Ridge Reservation to assure safe interim storage. Research and development activities at the Oak Ridge Reservation would increase from current levels. A new SNF management complex would be built, including (a) a SNF receiving and canning facility, (b) a technology development facility, (c) an interim dry storage area, and (d) an expended core facility similar to the one at the Idaho National Engineering Laboratory.

The SNF receiving and canning facility would receive SNF cask shipments from offsite and prepare the SNF for dry storage. A pool storage area would be included in this facility for cooling SNF before dry storage. The technology development facility would be used to investigate the applicability of dry storage technologies and pilot-scale technology development for disposition of the various types of SNF. The interim dry storage area would consist of passive storage modules designed to safely store the SNF for 40 years. Naval SNF would be examined at the new expended core facility at Oak Ridge before interim storage.

A small quantity of Molten Salt SNF is stored in tanks at the Oak Ridge Reservation. Currently, technology to stabilize this SNF for transport does not exist. Under this alternative, if the Oak Ridge Reservation were to transport SNF to the Savannah River Site, this Molten Salt SNF would continue to be stored at the Oak Ridge Reservation until it could be stabilized for safe transport.

If the Oak Ridge Reservation were not selected as the Eastern Regional Site, almost all SNF at the Oak Ridge Reservation would be transported to the Savannah River Site. Some SNF might not be transported until a stabilization process is developed because of the current inability to stabilize some SNF for transport. The option for acquiring dry storage facilities would support continued High Flux Isotope Reactor operation during the transition period.

3.1.4.5 Nevada Test Site.

Regionalization 4A would not affect the Nevada Test Site because fuel is not currently stored onsite and fuel would not be transported to the site.

If the Nevada Test Site were selected as the Western Regional Site for implementation of Regionalization 4B, SNF from western locations would be transported to the Nevada Test Site for storage. In addition, naval SNF might be transported to the Nevada Test Site if the Western Site were selected for naval fuel. SNF currently stored at other DOE facilities would arrive at the Nevada Test Site fully stabilized. New non-DOE domestic, foreign research reactor, and naval SNF would arrive in a state necessary for safe transportation but uncanned. This fuel would be stabilized, prepared, and canned at the Nevada Test Site to ensure safe interim storage. A new SNF management complex would be built including (a) an SNF receiving and canning facility, (b) a technology development facility, (c) an interim dry storage area, and (d) an expended core facility similar to the one at the Idaho National Engineering Laboratory (if Nevada Test Site were selected for receipt of naval fuel).

The SNF receiving and canning facility would receive SNF cask shipments from offsite and prepare the SNF for dry storage. A pool storage area would be included in this facility for cooling SNF, as necessary, before dry storage. The technology development facility would be used to investigate the applicability of dry storage technologies and pilot-scale technology development for disposal of the various types of SNF. The interim dry storage area would consist of passive storage modules designed to safely store the SNF for 40 years. Naval fuel would be examined at the new expended core facility at the Nevada Test Site before interim storage (if Nevada Test Site were selected for receipt of naval fuel).

If the Nevada Test Site were not selected as the Western Regional Site, then Regionalization 4B would not be applicable to the Nevada Test Site because it does not generate or store SNF.

3.1.4.6 Naval Nuclear Propulsion Program.

Regionalization 4A-Under Regionalization 4A, the management of naval SNF would be the same as for the 1992/1993 Planning Basis alternative. Naval SNF removed from naval reactors would continue to be transported to the Expended Core Facility at the Idaho National Engineering Laboratory for examination. Following examination, the SNF would be transferred to the Idaho Chemical Processing Plant for interim storage. Planned improvements for the Expended Core Facility, including additions to the Dry Cell Facility, would be completed.

Regionalization 4B-Under Regionalization 4B, naval reactors would continue to be defueled and refueled, and the SNF would be sent to either the Western or the Eastern Regional Site for examination and storage.

If the Idaho National Engineering Laboratory were selected as the Western Regional Site, then naval SNF would continue to be transported to the Expended Core Facility for examination. After examination, the SNF would be transferred to the Idaho Chemical Processing Plant for storage. If another site were chosen for storage, naval SNF would continue to be transported to the Expended Core Facility at the Idaho National Engineering Laboratory for examination until construction of a new nuclear fuel examination facility or modification of an existing facility to perform the examinations at the selected site. The new facility would provide capabilities equivalent to the Expended Core Facility at the Idaho National Engineering Laboratory.

3.1.4.7 Other Generator/Storage Locations.

Under Regionalization 4A, the activities at the other generator and storage locations are the same as indicated for the 1992/1993 Planning Basis alternative. The exact destination of SNF transported would vary depending on the fuel type under Regionalization 4A and on the generation/storage location under Regionalization 4B.

3.1.5 Centralization

Centralization Alternative

Manage all existing and projected SNF inventories at one site until ultimate disposition.

- Existing SNF would be transported to the centralized site.
- Naval fuel would be transported to, examined, and stored at the centralized site.
- Projected SNF receipts would be transported to the centralized site.
- SNF processing might need to be conducted. Other forms of

stabilization might occur to provide for safe storage and/or transport.
Facility upgrade/replacement and new storage capacity would be provided at the centralized site; stabilization facilities would be provided at the transporting sites.
Research and development would be undertaken for SNF management, including stabilization technology.

Under the Centralization alternative, the SNF that DOE is obligated to manage would be transported to a single location for management. Potential sites include the Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, Oak Ridge Reservation, and Nevada Test Site. Table 3-5 summarizes the basic actions at each site under this alternative. Consequently, this alternative has five options (Options A through E)-centralization at each of the five potential sites. For the five sites designated under the Centralization alternative, the following discussion comprises two parts. The first part addresses the implications for the site if it were selected as the receiving site (that is, the centralization site). The second part presents the implications to the site if it were not selected as the centralization site, but currently managed SNF would be transported to the centralized site.

Regardless of the option selected, new facilities would be built at the selected site to accommodate the increased inventories. Some SNF would require stabilization, such as canning, before transport. SNF facilities at the transporting sites would then be closed. Activities related to the processing of SNF, including research and development and pilot programs, would also be centralized. Figure 3-6 shows the movement of fuel from 1995 through 2035 under this alternative.

For consolidation at sites other than the Idaho National Engineering Laboratory, a new expended core facility with capabilities comparable to the one in Idaho would be constructed, and the Idaho facility would be closed. Naval SNF would continue to be transported to the Expended Core Facility at the Idaho National Engineering Laboratory during a transition period, pending construction of storage and examination facilities at the central site.

3.1.5.1 Hanford Site.

Under the Centralization alternative, Option A, DOE-controlled and naval reactor SNF would be transported to the Hanford Site. This would require the completion of

Figure 3-6. Spent nuclear fuel distribution, location, and inventory for the Centralization alternative.

the upgrades, increases, and replacements of storage capacity identified for the existing inventory under the Decentralization alternative, as well as of the additional capacity within those facilities or new facilities to accommodate the SNF from the other sites and possibly a stabilization facility.

New facilities would also be required to receive, handle, and store offsite fuel. In addition, a new facility for research and development and pilot programs would be required to support ultimate disposition. An expended core facility would also be built at the Hanford Site.

If the Hanford Site were not selected for storage, Hanford would have to consolidate and prepare onsite SNF for transport to the central site. Some of the SNF would require stabilization before offsite transport, which would require a new facility similar to the one described in the Decentralization alternative. Additional casks and associated handling equipment compatible with the receiving capabilities at the central site might also be required. After transport of the SNF, related facilities at the Hanford Site would be closed.

3.1.5.2 Idaho National Engineering Laboratory.

If Option B were selected under the Centralization alternative, the Hanford Site, the Savannah River Site, and other DOE facilities would characterize, stabilize, and can the SNF in containers compatible with dry storage at the Idaho Chemical Processing Plant. Naval SNF removed from naval reactors would be transported to the Expended Core Facility at the Idaho National Engineering Laboratory.

Projects and activities for storage of SNF would be similar to those described for the 1992/1993 Planning Basis alternative, except that accelerated schedules for the Increased Rack Capacity and Additional Increased Rack Capacity projects would be necessary to accommodate the increased fuel receipts. In addition, the schedule for the Dry Fuel Storage Facility project would have to be accelerated and its scope expanded.

DOE would conduct maximum SNF research and development. Similar to the Regionalization alternative, the Electrometallurgical Process Demonstration Project would continue at Argonne National Laboratory-West.

If the Idaho National Engineering Laboratory were not selected as the storage site, a canning and characterization facility would be constructed at the Idaho Chemical Processing Plant to stabilize the different types of Idaho National Engineering Laboratory SNF in various shipping casks and storage containers before transport to the selected DOE facility.

Like the No Action alternative, the CPP-603 Underwater Fuel Storage Facility pool inventory would be transferred to existing dry storage facilities until it is transported offsite. The dry fuels storage facility would not be built. SNF-related facilities at the Idaho National Engineering Laboratory would be closed, except for facilities directly supporting operating reactors, such as the Advanced Test Reactor canal or the Argonne National Laboratory-West Fuel Cycle Facility.

SNF-related research and development activities would be phased out, although the Electrometallurgical Process Demonstration Project would continue at the Argonne National Laboratory-West Fuel Cycle Facility (but would process only SNF currently on the site). Similar to the No Action alternative, naval SNF would not be transported to the Idaho National Engineering Laboratory, and the Expended Core Facility would be shut down.

3.1.5.3 Savannah River Site.

If Option C were selected under the Centralization alternative, the Savannah River Site would receive all DOE and naval SNF. Major new facilities, including an expended core facility for naval fuels, would have to be constructed. Near-term actions and options would be similar to those described for the Decentralization alternative.

The activities and options for management of the aluminum-clad fuel would be similar to those described for the Decentralization alternative. Fuels received from other sites would be stored.

The Receiving Basin for Offsite Fuels and reactor disassembly basins would be used to meet near-term storage requirements for the current inventory of Savannah River Site SNF in the same manner as described for the Decentralization alternative. The Savannah River Site would build large-capacity wet or dry storage facilities for the SNF received. In addition, SNF receiving, characterization, and canning facilities would be necessary, and an expended core facility would be built onsite for examination of naval SNF.

Projects would be initiated to design characterization, canning, and storage facilities for the fuel types that the Savannah River Site would manage. Additional research would be conducted to develop requirements for the ultimate disposition of the SNF.

If the Savannah River Site were not selected as the centralized storage site, it would have to transport onsite SNF to the central site after stabilizing any fuel that is not safe for transport. No new storage facilities would be necessary because the Savannah River Site would maintain the SNF in the existing pools (as described for the Decentralization alternative) until moving it to the characterization facility before transport. The Savannah River Site would construct new characterization and canning facilities to prepare the SNF for transport. In addition, research would be conducted on stabilization and transport of aluminum-clad fuel that is heavily corroded.

3.1.5.4 Oak Ridge Reservation.

If Option D were selected under the Centralization alternative, the Oak Ridge Reservation would receive DOE SNF stabilized and canned to the extent necessary for safe transportation. The SNF might need to be uncanned, stabilized, prepared, and recanned at the Oak Ridge Reservation, however, to ensure safe interim storage. New non-DOE domestic, foreign research reactor, and naval SNF would arrive in a form suitable for safe transportation. If necessary, this fuel would be stabilized, prepared, and canned at the Oak Ridge Reservation to ensure safe interim storage. Research and development activities would increase from current levels. A new SNF management complex would be built, including (a) an SNF receiving and canning facility, (b) a technology development facility, (c) an interim dry storage area, and (d) an expended core facility similar to the one currently at the Idaho National Engineering Laboratory.

The SNF receiving and canning facility would receive SNF cask shipments from offsite and prepare the SNF for dry storage. A pool storage area would be included in this facility for cooling SNF before it is placed into dry storage, as necessary. The applicability of dry storage technologies and pilot-scale technology development for ultimate disposition of the various types of SNF would be investigated in the technology development facility. The interim dry storage area would consist of passive storage modules designed to safely store the SNF. Naval SNF would be examined at the expended core facility before storage.

A small quantity of Molten Salt SNF is stored in tanks at the Oak Ridge Reservation. Currently, technology to stabilize this SNF for transport does not exist. Under this alternative, if the Oak Ridge Reservation were to transport SNF to the Savannah River Site, this Molten Salt SNF would continue to be stored at the Oak Ridge Reservation until it could be stabilized for safe transport.

If the Oak Ridge Reservation were not selected as the centralization site, then almost all SNF at the Oak Ridge Reservation would be transported to the centralization site. The option for acquiring dry storage facilities would support continued High Flux Isotope Reactor operation during the transition period.

3.1.5.5 Nevada Test Site.

If Option E were selected under the Centralization alternative, the Nevada Test Site would receive DOE SNF stabilized and canned to the extent necessary for safe transportation. (However, the SNF might need to be uncanned, stabilized, prepared, and recanned at the Nevada Test Site to ensure safe interim storage.) New non-DOE domestic, foreign research reactor, and naval SNF would arrive in a state necessary for safe transportation but uncanned. This fuel would be stabilized, prepared, and canned at the Nevada Test Site to ensure safe interim storage. A new SNF management complex would be built, including (a) an SNF receiving and canning facility, (b) a technology development facility, (c) an interim dry storage area, and (d) an expended core facility similar to the one currently at the Idaho National Engineering Laboratory.

The SNF receiving and canning facility would receive SNF cask shipments from offsite and prepare the SNF for dry storage. A pool storage area would be included in this facility for cooling SNF before it is placed into dry storage, as necessary. The applicability of dry storage technologies and pilot-scale technology development for disposal of the various types of SNF would be investigated in the technology development facility. The interim dry storage area would consist of passive storage modules designed to safely store the SNF for 40 years. Naval SNF would be examined at the expended core facility before interim storage.

If the Nevada Test Site were not selected as the centralization site, then this alternative would not be applicable to the Nevada Test Site because it neither generates nor stores SNF.

3.1.5.6 Naval Nuclear Propulsion Program.

Under the Centralization alternative, naval SNF would be transported to the selected site for examination and storage. If a site other than the Idaho National Engineering Laboratory were selected, then a transition period would be required, during which naval SNF would be transported to the Expended Core Facility at the Idaho National Engineering Laboratory and a new expended core facility at the central site would be constructed. No actions would be needed to prepare the naval SNF for storage because of its corrosion resistance, high integrity, and strength.

3.1.5.7 Other Generator/Storage Locations.

Under the Centralization alternative, SNF would be transferred from the other generator and storage locations to the central storage site. Although the shipment destination may vary, the impacts from SNF operations at these locations would be the same as those identified in the 1992/1993 Planning Basis alternative.

3.2 Alternatives Eliminated from Detailed Analysis

In the process of evaluating management alternatives available to the DOE, several other management concepts and technologies have been considered for incorporation into the programmatic alternatives described in Section 3.1. The following section describes the concepts and technologies considered and not carried forward and identifies why they have been eliminated from detailed analysis.

3.2.1 Examine or Store Spent Nuclear Fuel in Foreign Facilities

The design and operating characteristics of the fuel for naval reactors and certain portions of other SNF are classified. As such, they are not releasable to foreign interests without going through a complex procedure prescribed in the Atomic Energy Act and strict U.S. Nuclear Regulatory Commission licensing requirements. Some of these classified design details and characteristics are obvious from the physical form of the fuel, and others could be learned from detailed examination or analyses. The United States Nuclear Weapons Nonproliferation Policy is summarized in the White House Fact Sheet on Nonproliferation and Export Control Policy, dated September 27, 1993 (White House 1993). Under its nuclear nonproliferation policy, the United States seeks to reduce or eliminate, where possible, the accumulation of stockpiles of highly enriched uranium or plutonium. These factors, along with others such as the security required for foreign transport and storage, make this alternative impractical. Based on these considerations, this alternative was eliminated from detailed analysis.

3.2.2 Leave Naval Spent Nuclear Fuel in Nuclear-Powered Ships

It is physically possible to retain SNF in the reactors in nuclear-powered vessels and moor the ships at shipyards until a decision on the ultimate disposition of the SNF is determined and implemented, and the fuel could then be removed from the ships.

Implementing this alternative would require extensive modifications to facilities at shipyards, including increasing the number of piers and the availability of waterfront utilities to support the ships at their moorings. Other shipyard facilities also might have to be modified or replaced in order to moor the numbers of ships involved during the 40-year period. The construction of piers and other needed facilities would cause impacts on the waterfronts and harbors and could affect the local ecology. Shipyard facilities would become overloaded with the requirement to moor vessels retaining their SNF onboard and skilled shipyard staff would be unable to continue to work on the operational fleet.

In addition, the costs and impacts on national security resulting from such an approach would be large; it would affect the ability of the U.S. Navy to carry out its mission. The costs of maintaining the ships with SNF remaining installed under Navy operating procedures and of providing the additional piers, waterfront services, and utilities would be large, both for ships that are to be decommissioned and for ships that would normally be refueled and returned to duty. (Failure to remove the SNF from Navy ships that are still needed for service would result in these ships being unavailable once their currently installed reactor fuel reaches the end of useful life.)

3.2.3 Alternate Sites for the Management of Spent Nuclear Fuel

An alternative SNF site selection process was undertaken to identify alternatives to the three major DOE sites-Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site. The candidate sites evaluated, site selection screening process, and results are presented in the Alternate Site Selection Decision Process Report (DOE-ID 1994). This study concluded that the uncertainties regarding Department of Defense sites together with their lack of SNF facilities and expertise made these additional Department of Defense sites less attractive as site alternatives. The alternative SNF site selection process resulted in the addition of the Nevada Test Site and Oak Ridge Reservation as potential regionalization and centralization sites for SNF management. The Oak Ridge Reservation represented a reasonable alternative site to the Savannah River Site for regionalization of Eastern-based SNF and the Nevada Test Site represented a reasonable alternative site to the Idaho National Engineering Laboratory or Hanford sites for regionalization of Western-based SNF. These two sites also represented options for centralization of all SNF management activities. However, the DOE did not consider the Nevada Test Site to be a preferred site for the management of SNF because of the State of Nevada's current role as the host site for the Yucca Mountain Site Characterization Project and the Nevada Test Site's lack of SNF management facilities and high-level waste infrastructure. For purposes of conducting a thorough National Environmental Policy Act analysis, the Nevada Test Site provides a contrast to other potential sites because it represents a site that has no existing SNF infrastructure. Non-DOE sites were eliminated from further analysis.

3.2.4 Chemical Separation/Processing of Spent Nuclear Fuel

Three potential technical management options were evaluated for chemical separation/processing of DOE SNF. However, DOE will not select SNF technical management options on the basis of Volume 1 of this EIS. These technology-based decisions are most appropriately made after detailed analysis on a fuel type-specific or site-specific basis. The three options include (a) chemical separation/processing in DOE facilities at the Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site; (b) chemical separation/processing in foreign commercial facilities; and, (c) chemical separation/processing in domestic commercial facilities.

Chemical separation/processing at DOE sites was evaluated under certain alternatives as a reasonably foreseeable activity as a SNF stabilization technology. This activity is discussed in Section 3.1 of this EIS. However, the evaluation was limited to certain alternatives and certain fuel types based largely on historical technologies and capabilities. Future technology-based SNF management decisions would be made only after further National Environmental Policy Act reviews were completed.

Several foreign commercial facilities exist that have the capability to process certain types of DOE SNF. An analysis of processing DOE SNF at those facilities would have to consider United States nuclear nonproliferation policy (with regard to highly enriched uranium and plutonium), national security concerns (with regard to the classified nature of naval fuel), and other technical considerations (with regard to transportation of wet fuel, processing capability in foreign facilities, possible fuel instability, etc.). There are certain fuel types addressed in this EIS for which management by processing in a foreign facility may be considered appropriate. In such instances, final decisions on technology-based options would be made based on further analysis in other site-specific or fuel type-specific National Environmental Policy Act reviews tiered from this EIS. For example, in a separate EIS on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel, DOE addresses foreign processing of the foreign research reactor SNF included in this EIS as a potential management alternative.

In response to public comment, Appendix A, Volume 1 of this EIS includes an analysis of transporting N-Reactor and Single-Pass Reactor SNF currently stored at the Hanford Site to a site in England for processing. The impacts identified by this analysis are considered to be representative of the impacts of transporting and handling any specific DOE SNF that might be considered for foreign processing, because N-Reactor SNF is low-enriched SNF and is a large fraction (in MTHM) of the currently stored inventory. In addition, the analysis included transportation routes that maximize foreign and domestic distances. A summary of these transportation impacts is included in Appendix I, Volume 1 of this EIS.

Domestic commercial facilities are not available for SNF processing for interim storage and, therefore, were eliminated from further consideration.

3.2.5 Preparations for Disposal

DOE has not yet decided whether the ultimate disposition for DOE SNF is disposal in a repository or removal/recycle of the fissile material (primarily uranium). Disposal of SNF would require (a) development of the repository waste acceptance criteria, and (b) completion of the characterization of the various types of SNF that would allow a determination of the specific technology needed for SNF preparation (processing, canning, etc.) for each fuel type. Because of the large number of uncertainties at this time, it is considered too speculative to include in this EIS at this time. Therefore, preparation for disposal in a geologic repository was eliminated from further evaluation in this EIS.

3.3 Comparison of Alternatives

As discussed in Chapter 5 and the site-specific appendices, the environmental consequences and, therefore, differences among the five SNF management alternatives addressed in Section 3.1 would be small. The comparison of alternatives in this section concentrates on (a) the areas in which the public has expressed considerable interest, and (b) programmatic factors important to DOE decisionmaking. The following factors were selected for comparison:

Number of SNF shipments among sites

Public health effects

SNF-related employment
Generation of radioactive waste

Impact on DOE or Navy missions
Cost of implementation.

The alternatives that would cause the smallest impacts in these areas maximize the use of existing facilities, staff, and infrastructure.

3.3.1 Number of Shipments

Figure 3-7 shows the number of shipments that would occur under each alternative. Figure 3-7 also quantifies shipments of test specimens under each alternative. Shipments of naval test specimens are included here because of their contribution to cumulative impacts of naval SNF transportation. Details concerning naval test specimens and methodologies for calculating impacts of specimen shipments can be found in Appendix D. The No Action alternative would involve a limited number of naval spent fuel shipments (200) and test specimen shipments (320). The Decentralization alternative, 1992/1993 Planning Basis alternative, and Regionalization 4A alternative mostly involve shipments to DOE sites from the smaller reactor and storage sites and from the naval sites to DOE sites. These shipments range in number from approximately 2,300 shipments under Decentralization Options A or B to approximately 4,500 under the Regionalization 4A alternative. Decentralization Option C and the 1992/1993 Planning Basis alternative have approximately 3,200 and 3,700 shipments, respectively, over the 40-year period. For the Regionalization 4B alternative and the Centralization options, SNF is transported to one or two sites. For these alternatives and options, the number of shipments range from approximately 5,500 under the Regionalization 4B alternative (Idaho National Engineering Laboratory and Savannah River Site) to a high of about 9,200 under the Centralization Option E (centralization at the Nevada Test Site). The number of shipments is summarized in Table 3-6. A more detailed discussion can be found in Appendices D and I of Volume 1. The public health effects from such shipments are discussed in the next section.

Figure 3-7. Number of spent nuclear fuel and test specimen shipments between the years 1995 and 2035.

3.3.2 Public Health Effects

This section discusses the public health effects from radiation exposure and traffic accidents under DOE's SNF Management Program (see Section 5.1.1.4 for basic information regarding assessment methods). These effects are estimated to be small, as shown by Figures 3-8, 3-9, and 3-10. The three sources of radiation exposure are (a) normal site operations, (b) transportation, and (c) accidents. Under all alternatives, the estimated number of latent cancer fatalities from the operation of the entire DOE SNF management system over a 40-year period would range from approximately zero to about two latent cancer fatalities.

3.3.2.1 Normal Operations.

In general, the greatest radiation exposure from normal SNF site activities and incident-free transportation results when large quantities of SNF are transported among sites, such as under the Regionalization 4B alternative or Centralization alternative. Under incident-free transportation, as noted in Table 3-7, the estimated total fatalities are less than two for all alternatives, with the highest estimates associated with the Centralization options. This reflects the higher number of shipments associated with these options.

In summary, estimated radiation impacts on public health are small for all alternatives (which include many different siting options), and it would, therefore, not be possible to materially reduce the impacts through a site selection process.

3.3.2.2 Accidents.

Transportation accidents pose the lowest risk of cancer fatalities (although the consequences of some accidents can be high). The accident risks are presented in Table 3-8. The results indicated that the risks associated with traffic fatalities are greater than the risks associated with cancer caused by radiation exposure. Both normal site operations and incident-free transportation have greater risk than that expected from transportation accidents when the probability and the consequences of potential accidents are considered. The latent cancer fatalities associated with onsite accidents is small across alternatives. The transportation accident with the largest consequences would lead to 55 latent cancer fatalities; the probability of occurrence is 1.1 10-7 per year (1 in 10 million years) (see Appendix I).

In summary, for radiation-induced latent cancer fatalities to the public over 40 years of SNF management under all of the alternatives evaluated, the most likely outcome is as follows:

Essentially zero latent cancer fatalities from normal facility operations and facility accidents

Essentially zero latent cancer fatalities from transportation accidents

Table 3-6. Number of offsite spent nuclear fuel and test specimen shipments by alternative.

Alternative		Maximum number of shipments	
		Spent fuel shipments(a)	Test specimen shipment(b)
No Action		200	320
Decentralization	Option A	2,000	320
	Option B	2,000	320
	Option C	2,900	320
1992/1993 Planning Basis		2,900	760
Regionalization 4A		3,700	760
Regionalization 4B			
Hanford Site/Savannah River Site		4,800	1,750
Idaho National Engineering Laboratory/Savannah River Site		4,600	760

Nevada Test Site/Savannah River Site	6,600	1,750
Hanford Site/Oak Ridge Reservation	5,600	1,750
Idaho National Engineering Laboratory/Oak Ridge Reservation	5,400	760
Nevada Test Site/Oak Ridge Reservation	7,300	1,750
Centralization		
Hanford Site	5,700	1,750
Idaho National Engineering Laboratory	5,500	760
Savannah River Site	6,600	1,750
Oak Ridge Reservation	7,300	1,750
Nevada Test Site	7,400	1,750

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a. Assuming naval SNF shipments by rail and DOE SNF by truck.

b. Test specimens by truck.

Figure 3-8. Maximum estimated number of latent cancer fatalities per year in the general population from normal spent nuclear fuel site operations and total fatalities from incident-free transportation.

Figure 3-9. Estimate of risk of latent cancer fatalities in general population from facility accidents for spent nuclear fuel management activities.

Figure 3-10. Estimate of average annual riskb from transportation accidents for spent nuclear fuel management activities.

Table 3-7. Comparison of incident-free transportation total fatalities for alternatives over the 40-year period.

	Minimum(a,b) total fatalities	Maximum(b,c) total fatalities
No Action	0.0089	0.0089
Decentralization	0.12 to 0.15	0.35 to 0.38
1992/1993 Planning Basis	0.14	0.45
Regionalization 4A (fuel type)	0.17	0.61
Regionalization 4B (geography)		
Idaho National Engineering Laboratory and Savannah River Site	0.15 to 0.17	0.51 to 0.53
Idaho National Engineering Laboratory Ridge Reservation	0.14 to 0.15	0.53 to 0.54
Hanford Site and Savannah River Site	0.17	0.55 to 0.56
Hanford Site and Oak Ridge Reservation	0.15	0.57
Nevada Test Site and Savannah River Site	0.19	0.88
Nevada Test Site and Oak Ridge Reservation	0.17	0.90
Centralization		
Hanford Site	0.23	1.3
Idaho National Engineering Laboratory	0.21	1.1
Savannah River Site	0.26	1.7
Oak Ridge Reservation	0.21	1.6
Nevada Test Site	0.26	1.6

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a. The minimum total fatalities are associated with transport of DOE fuel by rail; naval SNF shipments are by both truck (onsite) and rail (offsite).

b. Total fatalities are for the 40-year period 1995 through 2035 and were the sum of the estimated number of radiation-related latent cancer fatalities for workers and the general population and the estimated number of nonradiological fatalities from vehicle emissions.

c. The maximum total fatalities are associated with transport of DOE fuel by truck; naval SNF shipments are by both truck (onsite) and rail (offsite).

Table 3-8. Comparison of estimated transportation accident risks for alternatives over the 40-year period.

Alternative	Truck accident risks(a)		Rail accident risks(a)	
	Latent cancer fatalities	Traffic fatalities	Latent cancer fatalities	Traffic fatalities
No Action	4.1 X 10^-6	0.047	4.1 X 10^-6	0.047
Decentralization(b)	0.00085 to 0.00090	0.20 to 1.01	0.00029 to 0.00034	0.26 to 1.07
1992/1993 Planning Basis	0.0010	0.70	0.00035	0.73
Regionalization 4A (fuel type)	0.0011	0.77	0.00037	0.76
Regionalization 4B (geography)				
Idaho National Engineering Laboratory and Savannah River Site	0.00090	0.72	0.00034	0.73
Idaho National Engineering Laboratory and Oak Ridge Reservation	0.00095	0.73	0.00024	0.72
Hanford Site and Savannah River Site	0.0013	0.84	0.00075	0.82
Hanford Site and Oak Ridge Reservation	0.0013	0.81	0.00050	0.78
Nevada Test Site and Savannah River Site	0.0012	0.99	0.00045	0.91
Nevada Test Site and Oak Ridge Reservation	0.0012	1.00	0.00035	0.91
Centralization				
Hanford Site	0.0050	1.10	0.0013	1.05
Idaho National Engineering Laboratory	0.0048	1.00	0.0013	0.95
Savannah River Site	0.0020	1.44	0.00080	1.09
Oak Ridge Reservation	0.0017	1.35	0.00055	1.00
Nevada Test Site	0.0050	1.33	0.0014	1.19

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a. Assumes SNF shipments are 100 percent by truck or 100 percent by rail, except for naval SNF shipments that are by both truck (onsite) and rail (offsite).

b. Range of values in each column for the Decentralization alternative reflects the different fuel examination options for naval SNF.

Up to about one latent cancer fatality from most incident-free transportation scenarios; up to two latent cancer fatalities under the Centralization options

Up to about two fatalities from nonradiological traffic accidents.

A more detailed discussion of accidents is found in Chapter 5, Volume 1 of this EIS.

3.3.3 Employment Related to Spent Nuclear Fuel Management at DOE and Naval Sites

Under various alternatives, the total labor force involved in SNF management could decrease by 180 jobs or increase by more than 2,100 jobs averaged over the period 1995 to 2005, as compared to the 1995 baseline. This labor force is the sum of permanent employment in operating or maintaining new facilities and shorter term construction jobs. Figures 3-11 and 3-12 characterize the range of SNF jobs under each alternative. The number of jobs related to SNF management is small compared with the total number of jobs (2 to 4.5 percent) at the sites that would be involved in SNF management. SNF management-related jobs account for less than 4.5 percent of total employment at the sites and less than 8 percent of employment at any one site.

It is important to note that the relocation of large amounts of SNF under the Regionalization 4B alternative and the Centralization options would eventually result in closure of SNF management facilities at major DOE sites and, therefore, long-term job loss at the closed facilities. However, some of the job losses at closed facilities would be accompanied by job gains at the sites receiving the fuel shipments. In addition, from 1995 to 2005 several management actions already initiated at various sites to maintain a safe storage configuration for existing SNF will be completed, and much of the SNF would need to be stabilized before transport. In the near term, the combination of building facilities at some sites and stabilizing SNF before transport at other sites complicates estimating the near-term SNF employment situation.

Under the No Action alternative, employment would not increase substantially at any site, and the closure of the Expended Core Facility at the Idaho National Engineering Laboratory would result in a net loss of just over 500 jobs involved in SNF management following closure. The maximum number of jobs indicated in Figure 3-11 assumes processing for stabilization and reports the maximum number for options at each site.

For any of the alternatives, no more than an average additional 2,100 jobs over the period 1995 to 2005 would be required for implementation. Some of the larger SNF employment requirements (particularly those involving the Hanford Site) would be caused by the development and operation of processing facilities needed to stabilize stored SNF. If processing were not undertaken, less employment would be generated at those sites. In addition, the relocation of the Expended Core Facility to sites other than the Idaho National Engineering Laboratory would result in an increase of about 500 jobs per year in the support of naval SNF examinations at those sites and would result in a corresponding loss of approximately 500 jobs at the Idaho National Engineering Laboratory. However, regionalization with the Nevada Test Site as the Western Regional Site and the Oak Ridge Reservation as the Eastern Regional Site would result in the highest employment peak. The peak, estimated to be approximately 4,600 jobs in the year 2000, includes employment at sites preparing SNF for transport to the selected sites.

Figure 3-11. Change in the number of jobs averaged over the years 1995 to 2005 for spent nuclear fuel management activities.

Figure 3-12. Change in site employment between the years 1995 and 2005 for spent nuclear fuel management activities as a percent of 1995 baseline.

A more detailed discussion of socioeconomic impacts can be found in Chapter 5, Volume 1 of this EIS.

3.3.4 Generation of Radioactive Wastes

When SNF is stored onsite, very little high-level, transuranic, or mixed waste is generated (see Figure 3-13). These small quantities of radioactive wastes would usually be generated during stabilization activities.

As a result, under the No Action alternative fewer than 20 cubic meters per year (26 cubic yards per year) of transuranic wastes would be generated from SNF management nationwide because SNF would not be stabilized. Under the other alternatives, where stabilization activities are assumed to occur, it is estimated that between 20 and 190 cubic meters (26 and 250 cubic yards) of high-level waste and between 20 and 90 cubic meters (26 and 120 cubic yards) of transuranic waste would be generated each year (Figure 3-13). The lower generation rates would occur in the Decentralization alternative, where small amounts of SNF would be transported among major DOE sites (and stabilization for transport would not be necessary). For other alternatives, greater amounts of SNF would be transported among sites; therefore, more SNF would require stabilization before transport and more waste would be generated. The difference between the minimum and maximum volume of waste generated results principally from the contribution attributable to processing for stabilization.

Low-level waste is also generated as a result of SNF management. Figure 3-14 indicates the estimated annual volume for each of the alternatives. As previously noted for high-level, transuranic, and mixed waste, the higher values are principally the result of processing for stabilization.

A more detailed discussion of radioactive waste generation under each alternative can be found in Chapter 5, Volume 1 of this EIS.

3.3.5 Impacts on DOE and Navy Missions

The concerns for the missions of DOE and the Navy relate to storing SNF safely, meeting obligations, preparing SNF for ultimate disposal, and examining naval SNF.

3.3.5.1 Impacts on DOE.

The DOE mission regarding the safe storage of SNF is impacted in the No Action alternative. Under this alternative, DOE will initially suffer from a loss of margin in storage capacity. In addition, DOE may be impacted by needing to make more frequent repairs to existing facilities (potentially losing the use of a facility because it is beyond repair). In time, there would be little or no flexibility for repairs under the No Action alternative.

Figure 3-13. Average volume of high-level, transuranic, and mixed waste generated per year over the years 1995 to 2005 for spent nuclear fuel management activities.

Figure 3-14. Average volume of low-level wastes generated per year over the years 1995 to 2005 for spent nuclear fuel management activities.

Additionally, by limiting research and development to activities already approved, DOE's ability to safely store SNF would be impacted by being unable to conduct new research and development. The No Action alternative would not permit development of processing and other technologies except for those underway as of June 1995.

Under the No Action alternative, DOE would not satisfy its obligations associated with SNF from university reactors, other research reactors, and special-case commercial SNF. Also, under the No Action alternative, DOE might not be able to fulfill agreements with states or other Federal agencies that involve SNF, except those specific actions already in progress, unless the agreements are changed. Failure to meet the terms of these agreements would expose DOE to adverse legal actions. In addition, DOE would not proceed, as it has proposed, to establish a new policy for management of foreign research reactor fuel that contains United States origin uranium (see Section 1.2.4). These mission impacts could be avoided under any alternative but the No Action alternative.

The DOE recognizes a need, which is not yet well defined, to prepare SNF for its ultimate disposition. At this point, the processing and other technology required for ultimate disposition are not precisely known.

Under the No Action alternative, no new facilities or new research and development would be allowed. The No Action alternative would not permit development of processing and other technologies except for those begun as of June 1995. Although the acceptance criteria for DOE-managed SNF have not yet been defined and repository disposal may permit canned SNF, alternative approaches for ultimate disposition must be developed. By not allowing this development under this alternative, DOE would be unable to meet one of the major goals of the SNF Management Program. For the No Action alternative, no facilities could be built for converting SNF to forms acceptable for disposition. In addition, with facilities storing SNF throughout the country, more canning or other processing facilities might be required than are currently planned. Building additional facilities at multiple locations would impede efficient disposition of SNF produced at small reactor sites. Other alternatives would allow research and development to proceed as deemed appropriate to support stabilization.

3.3.5.2 Impacts on the Navy.

The Navy would incur large storage costs under the No Action and Decentralization alternatives. In addition, the Navy mission would be hindered if the full examination of fuels at an expended core facility were not possible. Full examination would not happen under the No Action alternative and Decentralization Options A and B. The examinations are a critical aspect of the Naval Nuclear Propulsion Program's ongoing advanced fuel research and development program. They provide engineering data on nuclear reactor environments, material behavior, and design performance. These data support

The design of new reactors having extended lifetimes

Continued safety of naval reactors

Improvements in nuclear fuel performance and ship operational performance

The operation of existing naval reactors by providing confirmation of their proper design and allowing maximum depletion of their fuel.

The verification of engineering methods and models to design naval nuclear fuel.

Although it is difficult to quantify the benefits of an outstanding safety record and improved operational characteristics, increased core life yields an economic advantage-a reduction in the number of reactor cores that must be procured and in the number of refuelings that must be performed. It also results in less SNF being generated. Another advantage is the increased online availability of nuclear-powered ships with life-of-ship fuel, which would reduce the number of ships required. About $5 billion would be saved if life-of-ship fuels are developed, based on an assumed force structure of fewer than 100 nuclear-powered ships by 2005. Additional details can be found in Appendix D, Volume 1 of this EIS.

3.3.6 Cost of Implementation

The DOE prepared and issued in March 1995 a cost evaluation report (DOE 1995b) that provides insight for short- and long-term planning for DOE complex-wide SNF management. This report was also used to provide costs relevant to this EIS. This section provides potential costs associated with the management of DOE SNF for the 40-year period evaluated in this EIS.

3.3.6.1 Results.

Table 3-9 provides a range of costs for interim storage. Because of the very broad scope associated with complex-wide SNF management and the uncertain nature of future actions, "best estimate" costs cannot be developed at this time. The degree to which existing facilities factor into a given alternative can vary. To account for this, each alternative was analyzed for two cost ranges to define the possible spread of cost for each alternative. The upper and lower cost ranges were defined as follows:

Upper Cost Range - Assumed construction of new facilities, except for a limited number judged adequate for 40 years.

Lower Cost Range - Assumed existing facilities used at the Idaho National Engineering Laboratory and the Savannah River Site but no existing facilities used at Hanford. Facility upgrades were limited to Phase III vulnerability costs (DOE 1994c).

Table 3-9. Cost results for storage only (billions of dollars).

Alternatives	Upper range	Lower range
No Action (1)	17.4	10.6
Decentralization-no examination (2A)	17.9	8.6
Decentralization-limited examination (2B)	18.1	8.9
Decentralization-full examination (2C)	20.1	10.8
1992/1993 Planning Basis (3)	18.0	9.4
Regionalization by fuel type (4A)	17.6	9.1
Regionalization by geography (4B)a	16.0	9.6
Centralization at Hanford (5A)	15.4	13.5
Centralization at Idaho National Engineering Laboratory (5B)	13.8	11.9
Centralization at Savannah River Site (5C)	15.1	9.5
Centralization at Oak Ridge Reservation (5D)	17.1	15.1
Centralization at Nevada Test Site (5E)	17.5	15.3

a. All options were considered, however, only Idaho National Engineering Laboratory and Savannah River Site costs are shown.

3.3.6.2 Discussion and Conclusions.

Table 3-9 shows that Alternatives 1, 2A, 2B, 3, or 4A are roughly equivalent. This is because most of the SNF would be located at the same sites (Hanford, Idaho National Engineering Laboratory, and Savannah River Site) in each alternative. Alternative 4B costs less than Alternative 3 because all SNF would be moved to two sites (Idaho National Engineering Laboratory and Savannah River Site), which have existing infrastructures, and economies of scale (fewer sites cost less) dictate that two sites would be less costly than three. The table also shows that if new facilities are required, it would be least expensive to centralize SNF management at a site with existing SNF management infrastructure (that is, Alternatives 5A, 5B, or 5C). Transportation costs, which are typically 1 percent of total costs, would not be an overriding consideration in the selection of locations for SNF management.

In the lower cost range, if existing facilities can continue to be used, it would be least expensive to manage fuel under alternatives that maximize the use of sites with existing capabilities (that is, Alternatives 2A, 2B, 4A, or 4B). The centralization alternatives, which would require the construction of storage facilities, could cost up to $6.7 billion more that the least costly alternative (2A). Before drawing conclusions based on the lower cost range results, however, the reader should recognize that the selection of an approach using existing facilities, combined with a commitment to upgrade facilities [over and above correction of vulnerabilities (DOE 1994c)] may significantly change the cost comparisons. In this situation, cost would tend to increase toward the upper cost range.

Additional details can be found in DOE (1995b). This report is available in the DOE Public Reading rooms listed in the EIS, or upon request from the Office of Communications, DOE Idaho Operations Office at the address listed in the front of the EIS.

3.3.7 U.S. Nuclear Regulatory Commission Licensing Standards

DOE is proceeding with actions to implement safe, efficient, and cost-effective interim storage of its SNF before final disposition. The need for interim storage has led DOE to evaluate storage technologies and alternative management strategies to provide an optimum solution to storage challenges. Several commercial storage technologies under evaluation for DOE SNF have been licensed and regulated by the U.S. Nuclear Regulatory Commission. In addition, DOE SNF could eventually come under the jurisdiction of the U.S. Nuclear Regulatory Commission if it is to be disposed of in a geologic repository. Therefore, DOE is considering having any new interim storage facilities reviewed to determine whether they could meet U.S. Nuclear Regulatory Commission licensing standards. This approach, if implemented, would provide a testing ground for the development of the technical and administrative protocols between the U.S. Nuclear Regulatory Commission and DOE in the event that some type of U.S. Nuclear Regulatory Commission regulatory oversight occurs in the future.

4. AFFECTED ENVIRONMENT

This chapter contains overviews of the potentially affected environments at and around the existing and potential sites under consideration for management of SNF within the various alternatives addressed in the EIS. Because of the large amount of information necessary to adequately characterize the affected environments at these sites, the space available in this chapter limits the presentations to summaries of the relevant key site characterization information. Consequently, the detailed descriptions of the affected environments are presented under separate cover as self-contained appendices to Volume 1. This approach allows the reader to compare the relative similarities and differences among the sites without having to review thousands of pages of text. These separate site-specific appendices also contain the detailed analyses of environmental impacts associated with each alternative that are rolled up and summarized in Chapter 5.

The site-specific appendices under separate cover are organized as follows:

Appendix	Focus of appendix
A	Hanford Site
B	Idaho National Engineering Laboratory
C	Savannah River Site
D	Naval Nuclear Propulsion Program
E	Other Generator/Storage Locations
F	Nevada Test Site and Oak Ridge Reservation

This chapter focuses on details about resources most likely to be affected by the actions evaluated under the various alternatives. Consequently, not every category of information addressed in the site-specific appendices is rolled up for presentation here.

4.1 Hanford Site

This section summarizes the environmental characterization information on the Hanford Site, Richland, Washington. This information has been used in evaluating environmental impacts that might result from implementing the various alternatives for management of SNF at the Hanford Site. More detailed information characterizing the affected environment of the Hanford Site is presented in Appendix A, under separate cover.

The Hanford Site covers about 1,450 square kilometers (560 square miles) of the southeastern part of the State of Washington (see Figure 4-1). It is located in parts of Benton, Grant, and Franklin Counties. The nearest city is Richland, Washington, which borders the Hanford Site on its southeast corner. About 380,000 people live within an 80-kilometer (50-mile) radius of the Hanford Site.

The population within 80 kilometers (50 miles) of the Hanford Site has been characterized for the purposes of identifying whether any disproportionately high and adverse impacts exist to minority and low-income communities. The population surrounding the Hanford Site is shown to be 20 percent minority and 18 percent low-income, based on U.S. Bureau of Census information and the definitions and approach presented in Appendix L.

Approximately 6 percent of the Hanford Site is occupied by operational facilities. Waste management and SNF processing activities and waste storage occur near the center of the Hanford Site. Eight retired plutonium production reactors and the N Reactor are located on the south side of the Columbia River, and the nuclear research and development laboratories are located in the southeastern part of the Hanford Site near the city of Richland. The majority of Hanford's SNF is stored in basins in 100-KW and

100-KE. The Fast Flux Test Facility is located in the east-central area of the Hanford Site. The remaining area is undeveloped land that provides for buffer zones for the operating areas. The Hanford Site is a Superfund site, listed on the National Priority List.

The land adjacent to the Hanford Site is either urbanized or agricultural. Agricultural areas include irrigated and dry-land farming and grazing.

In 1992, the Hanford Site employed 16,100 people, accounting for almost 25 percent of the nonagricultural employment in Benton and Franklin Counties. Other major employers include the Siemens Nuclear Power Corporation, Sandvik Special Metals, Iowa Beef Processors, Boise Cascade, and Burlington Northern Railroad.

As of 1992, 248 prehistoric archaeological sites were recorded by the Hanford Cultural Resources Laboratory of the Pacific Northwest Laboratory. Of the 48 sites on the National Register of Historic Places, two are single sites and the remainder are in seven archaeological districts. Archaeological sites include remains of numerous pithouse villages, campsites, cemeteries along the river banks, spirit quest monuments, hunting camps, game drive complexes, quarries in mountains and rock bluffs, hunting/kill sites in lowland stabilized dunes, and small temporary camps near perennial sources of water away from the river. Native Americans have inhabited the land around the Hanford Site since prehistoric times. The Wanapum and the Chamnapum bands of the Yakama tribe were the area's primary inhabitants, being joined by Palus people, Walla Walla people, and Umatilla people for fishing the Hanford Reach of the Columbia River. These people retain traditional secular and religious ties to the region. Some native plant and animal foods, which are used in religious ceremonies performed by members of the Washane or Seven Drums religion, can be found on the Hanford Site.

Figure 4-1. Hanford Site location and site map.

The Hanford Site is on a low-lying, modified alluvial plain of the Columbia River. Altitudes range from about 105 meters (345 feet) in the southeast part to about 245 meters (804 feet) in the northwest corner. The Hanford Site is bounded to the east by the Columbia River and the White Bluffs of the Ringold Formation, to the southeast by the city of Richland, to the west by the Rattlesnake Hills, and to the north by the Saddle Mountain.

The principal geologic features beneath the Hanford Site, listed from the oldest to the youngest, include the Columbia River Basalt Group (basaltic lava flows), the Ringold Formation (weakly cemented coarse sandy gravel to compacted silt and clay), and a series of deposits called the Hanford formation (coarse gravel and sand). These units are covered by a few meters or less of recent alluvial or windblown sands. Other than gravel, there are no geologic resources of economic value on the Hanford Site.

The area of the Hanford Site is historically of low-to-moderate seismicity. On a scale of 0 to 4, the Hanford Site is in a Uniform Building Code Seismic Risk Zone 2B. (Zone 0 represents little damage, and is subject to the greatest seismic risk.) The largest seismic shock near the Hanford Site on record was approximately 4.5 to 5.0 on the Richter scale and Modified Mercalli Intensity of V; it was recorded in Corfu, 35 kilometers (22 miles) north of the Hanford Site in 1918. A Modified Mercalli Intensity V quake occurred in 1973. Many lower intensity earthquakes have occurred in the Columbia Plateau and on the Hanford Site as part of "earthquake swarms," which are clusters of several small earthquakes occurring over a short period of time.

The Hanford Site is located approximately 160 kilometers (100 miles) to the east of the Cascade Range, which includes several volcanic vents. The great distance eliminates the potential for lava flows from these volcanoes reaching the Hanford Site. The foreseeable volcanic effects at the Hanford Site are limited to windborne volcanic ash.

The general climate of the Hanford Site is hot and dry in summer and cool in winter. The average annual precipitation is 16 centimeters (6.3 inches), most of which falls during the winter. On average, thunderstorms occur 11 days per year, mostly during the summer. Tornadoes are extremely rare, occurring within 160 kilometers (100 miles) of the Hanford Site about once in 3 years. Air quality in the Hanford region is well within the State of Washington and U.S. Environmental Protection Agency standards for criteria pollutants, except that short-term particulate concentrations occasionally exceed the PM-10 standard. (PM-10 is particulate matter defined as suspended particulates with an aerodynamic diameter less than 10 micrometers.) The Class I Area (areas where degradation of air quality is to be severely restricted) nearest to the Hanford Site is at Goat Rocks Wilderness Area, 145 kilometers (90 miles) away.

Two rivers pass through or near the Hanford Site. The Columbia River passes through the northern part of the Hanford Site and forms part of the eastern boundary. The average daily flow of this river is 3,400 cubic meters per second (120,100 cubic feet per second). The Yakima River, with an average flow of 104 cubic meters per second (3,673 cubic feet per second), is located near the southern portion of the Hanford Site. Wastewaters are discharged to several ponds on the Hanford Site and the Columbia River. In addition to these surface waters, there are two intermittent creeks that form the remainder of the surface waters on the Hanford Site. The flood areas of these rivers and streams include some areas where facilities are located, but flooding is well-controlled by upstream dams on the Columbia River. Minor flooding (away from facilities) occurs from other watercourses. While specific information on the 100-year floodplain has not been defined, the projected extent of the maximum probable flood, which is greater than the area of inundation expected from a 100-year flood, would not impact proposed SNF facilities. More details on flooding, including that induced by dam failures, are given in Section 4 of Appendix A of Volume 1.

The water quality of the Columbia River is high, with minor increases in constituents resulting from Hanford Site discharges. Radiological monitoring shows low levels of radionuclides in samples of Columbia River water. Tritium, iodine-129, and uranium are found in somewhat higher concentrations downstream of the Hanford Site than upstream, but are well below concentration guidelines established by the U.S. Environmental Protection Agency drinking water standards. Nonradiological water quality parameters measured during 1989 were similar to those reported in previous years and were within Washington State Water Quality Standards.

Part of the water supply at the Hanford Site and for the nearby Tri-Cities is the Columbia River. In 1991, the combined water use for Richland, Pasco, and Kennewick was 4.3 107 cubic meters (11.38 billion gallons). Richland and Kennewick derive a portion of their water used from nearby groundwater wells and rely on groundwater as a sole source of water from November through March each year. Additional references and more detailed information on groundwater are in Appendix A of Volume 1.

In 1993, several radionuclides and nonradioactive chemicals were present in unconfined aquifers located beneath the Hanford Site in some locations at levels exceeding U.S. Environmental Protection Agency drinking water standards and/or DOE Derived Concentration Guides. These constituents are listed, as follows: radiological constituents-tritium, strontium-90, cobalt-60, antimony-125, technetium-99, iodine-129, cesium-137, uranium, and plutonium; and nonradiological constituent-nitrate, chromium, trichloroethylene, cyanide, fluoride, carbon tetrachloride, and chloroform. Groundwater beneath the Hanford Site is not used for human consumption or food production with the exception of a well utilized for drinking at the Fast Flux Test Facility visitor center. Above-background levels of tritium and iodine-129 have been detected in this well; however, these levels are well below U.S. Environmental Protection Agency drinking water standards.

DOE asserts a federally reserved water withdrawal right with respect to the Hanford Site operations. Current withdrawals from the Columbia River occur under this assertion. Of the water consumed from surface waters in the vicinity of the Hanford Site, 13 percent is used for industrial purposes. The Hanford Site uses 41 percent of the water targeted for industrial use.

The Hanford Site is a shrub-steppe environment dominated by cheatgrass and sagebrush, but it includes 10 different types of plant communities. This plant environment supports 12 species of amphibians and reptiles, 39 species of mammals, and numerous bird and insect species. Deer and elk are the major large animals, and coyotes are the major mammalian predators. Wetlands of varying size exist along the Columbia River and support extensive stands of willows, grasses, aquatic plants, and other plants. In the Hanford Reach of the Columbia River, 44 species of fish have been identified. The Hanford Reach is also used by various salmon and trout species as a spawning area and a migration route to and from upstream spawning areas. Four threatened or endangered plants classified by the State of Washington exist on the Hanford Site, as well as seven species of threatened or endangered birds or mammals and one insect species. The insect species and three of the bird species are federally listed.

No federally listed threatened or endangered species have been observed at the proposed SNF site. However, two Federal and/or state candidate species, the loggerhead shrike (Federal and state candidate) and sage sparrow (state candidate), were observed during a survey of the proposed SNF site. The sagebrush habitat at the proposed site is considered priority habitat by the State of Washington for the loggerhead shrikes, sage sparrows, burrowing owls (state candidate), pygmy rabbits (Federal candidate and state threatened), sage thrashers (state candidate), western sage grouse (Federal and state candidate), and sagebrush voles (state monitored). Although burrowing owls were not observed at the site, ground squirrel burrows used by burrowing owls and owl pellets were observed during the survey. No evidence of the other species were found at the proposed site. The closest known ferruginous hawk (Federal candidate and state-threatened species) nest is approximately 8.9 kilometers (5.5 miles) northwest of the site. The proposed site should be considered as comprising a portion of the foraging range of this species.

The Tri-Cities (Richland, Kennewick, and Pasco) serve as a regional transportation center with major air, land, and river connections. The Tri-Cities area has four major highways: U.S. Routes 12 and 395, State Route 240, and Interstate 82. State Route 240 traverses the Hanford Site from southeast to northwest. The Burlington Northern and Union Pacific railroads connect the area to more than 35 states. Docking facilities exist at the ports of Benton, Kennewick, and Pasco. The Tri-Cities Airport, located in Pasco, provides daily passenger and freight services.

For the years 1991 to 1993, the potential collective dose to the population within 80 kilometers (50 miles) from all Hanford Site effluents was calculated to be 0.9, 0.8, and 0.4 person-rem, respectively. In 1993, the dose to the maximally exposed offsite individual was calculated to be 0.00003 rem (0.03 millirem) per year from all exposure pathways. For perspective, collective dose to the same population from natural background radiation was calculated to be about 100,000 person-rem from an average individual dose of 0.3 rem (300 millirem) per year.

In 1993, about 14,500 individuals were monitored at the Hanford Site. Of those monitored, 11,000 were classified as radiation workers with a collective dose of 200 person-rem and an average annual dose equivalent of 0.02 rem (20 millirem) per individual with measurable doses. A subset of Hanford radiation workers associated with SNF storage at 100 K Basins averaged doses of 0.4 rem (400 millirem) per year. These averages are well below the 10 CFR Part 835 radiation dose limit of 5 rem (5,000 millirem) per year and the DOE Administration Control Level of 2 rem (2,000 millirem) per year for occupational exposure.

Electricity in the region is provided by several different entities, but it is ultimately generated by the Bonneville Power Administration. About 74 percent of the region's installed generating capacity is hydroelectric. Power for the Hanford Site is purchased wholesale from the Bonneville Power Administration, amounting to greater than 550 megawatts in 1988. Because of the reliance on hydropower, annual production is variable, averaging 16,400 megawatts of capacity.

Major incorporated areas in Benton and Franklin Counties are served by municipal wastewater treatment systems. The unincorporated areas are served by onsite septic systems.

High-level radioactive waste has been accumulating at the Hanford Site since 1944 in 149 single-shell tanks-no new waste has been added to these tanks since 1980. Much of the liquid waste from single-shell tanks has been transferred to newer double-shell tanks for safer storage. Transuranic wastes were disposed of onsite before 1970 in unlined trenches. Since 1970, transuranic wastes have been stored in abovegrade storage facilities. As of 1991, there were about 120,000 cubic meters (157,000 cubic yards) of transuranic waste buried or in retrievable storage. Mixed low-level waste totaling 16,745 cubic meters (21,902 cubic yards) was buried at the Hanford Site from 1987 to 1991. Another 4,225 cubic meters (5,526 cubic yards) of mixed waste has accumulated in storage. In 1992, 56,245 kilograms (124,000 pounds) of mixed low-level waste was generated. From 1944 to 1991, approximately 558,916 cubic meters (731,030 cubic yards) of low-level waste was buried at the Hanford Site. In 1991, 5,300 cubic meters (6,932 cubic yards) of low-level waste was generated at the Hanford Site. In 1992, 619,268 kilograms (1,365,000 pounds) of hazardous waste was generated. Mixed wastes are 99 percent tank wastes at the Hanford Site resulting from 108 different waste streams. Hazardous wastes generated in 1995 from SNF are expected to total 2.2 cubic meters (2.9 cubic yards). In 1992, industrial solid waste totaled 22,213 cubic meters (29,054 cubic yards) and asbestos totaled 1,017 cubic meters (1,330 cubic yards). A total of 1,484 hazardous chemicals are reported at the Hanford Site at over 783 locations, and they are found in 2,926 different hazardous materials. In 1992, the Emergency Planning and Community Right-to-Know Act reporting threshold was exceeded for 53 hazardous chemicals.

4.2 Idaho National Engineering Laboratory

This section summarizes environmental characterization information on the Idaho National Engineering Laboratory. This information has been used to evaluate impacts at the Idaho National Engineering Laboratory under various alternatives for management of SNF. More detailed information characterizing this Idaho National Engineering Laboratory is presented in Appendix B, under separate cover.

The Idaho National Engineering Laboratory is located on approximately 2,300 square kilometers (890 square miles) of land in southeastern Idaho and contains nine major facility areas (see Figure 4-2). It is located primarily within Butte County, but portions of the Idaho National Engineering Laboratory are also located in Bingham, Jefferson, Bonneville, and Clark Counties. The Idaho National Engineering Laboratory is roughly equidistant from Salt Lake City, Utah, and Boise, Idaho. Cities near the Idaho National Engineering Laboratory include Idaho Falls to the east, Blackfoot to the southeast, Pocatello to the south-southeast, and Arco to the southwest. Yellowstone National Park is 149 kilometers (90 miles) to the east.

Categories of land use at the Idaho National Engineering Laboratory include facility operations, grazing, general open space, and infrastructure, such as roads. About 2 percent of the total Idaho National Engineering Laboratory area [4600 hectares (11,400 acres)] is used for facilities and operations. The Idaho National Engineering Laboratory is a Superfund site, listed on the National Priority List.

The region of influence for the Idaho National Engineering Laboratory is a seven-county area comprising Bingham, Butte, Bonneville, Clark, Jefferson, Bannock, and Madison counties. The region of influence had a 1990 population of 219,713. Historically, the regional economy has relied predominantly on farming and ranching. Mining is also an important component of the regional economy.

The population within an 80-kilometer (50-mile) circle centered at Argonne National Laboratory-West on the Idaho National Engineering Laboratory has been characterized for the purposes of identifying whether any disproportionately high and adverse impacts exist to minority and low-income communities. The population surrounding the Idaho National Engineering Laboratory is shown to be 7 percent minority and 14 percent low-income, based on U.S. Bureau of Census information and the definitions and approach presented in Appendix L.

During fiscal year 1990, the Idaho National Engineering Laboratory directly employed approximately 11,100 personnel, accounting for almost 12 percent of the total regional employment. Approximately 38,000 persons, or 17 percent of the total regional population, were directly supported by employment associated with the operation of the Idaho National Engineering Laboratory. In 1992, the total direct Idaho National Engineering Laboratory employment was approximately 11,600 jobs. The total number of jobs at the Idaho National Engineering Laboratory is projected to decrease to approximately 8,620 in fiscal year 1995 and to approximately 7,250 in fiscal year 2004.

More than 1,500 prehistoric and historic archaeological resources have been identified in the Idaho National Engineering Laboratory area, but only 4 percent of the Idaho National Engineering Laboratory has been surveyed, mostly near major facility areas. The resources identified include prehistoric and historic sites and isolates. Although not formally evaluated, these sites are considered potentially eligible for nomination to the National Register of Historic Places; the isolates have been categorized as unlikely to meet eligibility requirements. The Experimental Breeder Reactor-I is listed on the National Register of Historic Places, and other structures could potentially be listed. The Shoshone-Bannock Tribes are the region's primary Native American residents. Because they believe the land is sacred, the entire Idaho National Engineering Laboratory reserve is potentially culturally important to them. Cultural resources, to the Shoshone-Bannock peoples, include all forms of traditional lifeways and usage of all natural resources. This includes not only prehistoric archaeological sites, which are important in religious or cultural heritage context, but also features of the natural landscape, air, plant, water, or animal resources that might have special significance. DOE has committed to additional interaction and exchange of information with the Shoshone-Bannock Tribes at the Fort Hall Reservation.

Figure 4-2. Idaho National Engineering Laboratory location and site map.

The northwestern edge of the Eastern Snake River Plain, where the Idaho National Engineering Laboratory is located, is bordered on the north and west by the Bitterroot, Lemhi, and Lost River mountain ranges. A number of inactive volcanic buttes also form part of the Idaho National Engineering Laboratory landscape.

The Eastern Snake River Plain forms a broad, northeast-trending, crescent-shaped trough with low relief comprised primarily of basaltic lava flows. These flows at the surface range in age from 1.2 million to 2,100 years. The surface of the Eastern Snake River Plain is comprised primarily of basaltic lava flows with thin, discontinuous, interbedded deposits of wind-blown loess and sand, waterborne alluvial fan and floodplain alluvial sediments, and rhyolitic domes formed 1,200,000 to 300,000 years ago.

The Eastern Snake River Plain is on an area of low seismicity that is adjacent to the seismically active Intermountain Seismic Belt and Centennial Tectonic Belt and lies in Uniform Building Code Seismic Risk Zones 2B and 3. The largest recorded earthquake in the Centennial Tectonic Belt occurred on October 28, 1983, near Borah Peak, Idaho, and had a moment magnitude of 6.9 (surface wave magnitude of 7.3). The epicenter was about 90 to 100 kilometers (56 to 68 miles) from the Idaho National Engineering Laboratory. The largest recorded earthquake within the Intermountain Seismic Belt surface wave (Richter scale magnitude 7.5) occurred on August 17, 1959, near Hebgen Lake, Montana, with an epicenter 145 kilometers (90 miles) northeast of the Idaho National Engineering Laboratory. In addition to these earthquakes, a total of 29 earthquakes greater than magnitude 5.5 have occurred within 322 kilometers (200 miles) of the Idaho National Engineering Laboratory since 1884. The Idaho National Engineering Laboratory lies in a potentially active but long-time dormant volcanic area. The conditional probability of basaltic volcanism affecting a south-central area of the Idaho National Engineering Laboratory is one incident in 40,000 to 100,000 years. The probability of volcanic impact on Idaho National Engineering Laboratory facilities further north is estimated to be less than one incident in every million years or longer.

Within Idaho National Engineering Laboratory boundaries, the geologic resources found or produced are sand, gravel, and pumice. Several quarries or pits maintain supply material for various onsite construction projects.

The general climate of the Idaho National Engineering Laboratory is characterized by average seasonal temperatures that range from -7.3C (18.8F) in winter to 18.2C (64.8F) in summer, with an annual average temperature of about 5.6C (42F). Annual precipitation is light, averaging 221 millimeters (8.71 inches). Snowfall averages 701 millimeters (27.6 inches) per year.

Although the Idaho National Engineering Laboratory is in a belt of prevailing westerlies, these winds are normally channeled by the adjacent mountain ranges into southwest wind. The annual average windspeed measured at the 6.1-meter (20-foot) level at the Central Facilities Area weather station is 3.4 meters per second (7.5 miles per hour). Monthly average values range from 2.3 meters per second (5.1 miles per hour) in December to 4.2 meters per second (9.3 miles per hour) in April and May. The highest hourly average nearground windspeed measured at the Idaho National Engineering Laboratory is 22.8 meters per second (51 miles per hour).

Severe weather, other than thunderstorms, is uncommon. Five funnel clouds (that is, tornadoes not touching the ground) and no tornadoes have been reported between 1950 and 1988.

Neither the Idaho National Engineering Laboratory nor the surrounding counties is designated as a nonattainment area (40 CFR Part 81.313) with respect to any of the National Ambient Air Quality Standards (40 CFR Part 50). The Idaho National Engineering Laboratory is located in a Class II area. Three prevention of significant deterioration (40 CFR Part 52.21) Class I ambient air quality areas have been designated in the vicinity of the Idaho National Engineering Laboratory: Craters of the Moon Wilderness Area, Idaho, 53 kilometers (33 miles) west-southwest from the center of the Idaho National Engineering Laboratory; Yellowstone National Park, Idaho-Wyoming, 143 kilometers (89 miles) east northeast from the center of the Idaho National Engineering Laboratory; and Grand Teton National Park, Wyoming, approximately 145 kilometers (90 miles) east from the center of the Idaho National Engineering Laboratory.

The types and amounts of nonradiological emissions from Idaho National Engineering Laboratory facilities and activities are similar to those of other industrial complexes of similar size. Baseline concentrations from criteria and hazardous/toxic air pollutants are within applicable standards and guidelines. Radioactive emissions occur from Idaho National Engineering Laboratory facilities; the calculated annual dose to the maximally exposed offsite individual is 0.00005 rem (0.05 millirem).

Essentially no surface water bodies drain the Idaho National Engineering Laboratory-all creeks and streams arise in the mountains and much of their water is diverted for irrigation. There is little flow of water onsite. Water that does reach the Idaho National Engineering Laboratory through the Big Lost River flows past the Test Reactor Area/Idaho Chemical Processing Plant area before going below ground or may be diverted by an onsite dam during heavy flows onto the southern part of the Idaho National Engineering Laboratory. The remainder of the water infiltrates near Test Area North. All rivers and streams are intermittent. No surface water runs off of the Idaho National Engineering Laboratory.

The Idaho National Engineering Laboratory does not withdraw or use surface water for operations, nor does it discharge effluents to natural surface water. However, the three surface water bodies at or near the Idaho National Engineering Laboratory (Big and Little Lost Rivers and Birch Creek) have the following designated uses: agricultural water supply, cold-water biota, salmonid spawning, and primary and secondary contact recreation. In addition, waters in the Big Lost River and Birch Creek have been designated for domestic water supply and as special resource waters.

Depths to the water table at the Idaho National Engineering Laboratory range from 61 meters (200 feet) in the north to 274 meters (900 feet) in the south. Flows in the largely unconfined Snake River Plain Aquifer are generally to the southwest. Groundwater flows at speeds ranging from 1.5 to 6.1 meters per day (5 to 20 feet per day). The water quality of the aquifer is generally good, and it is designated a sole source aquifer. As of 1992, concentrations of iodine-129, cobalt-60, strontium-90, and cesium-137 had exceeded the U.S. Environmental Protection Agency's maximum contaminant levels for drinking water established for radionuclides in localized areas within the aquifer inside the Idaho National Engineering Laboratory boundary. However, concentrations of these radionuclides in groundwater are generally decreasing over time. This decrease is attributed to improved waste management practices, reduced discharges, adsorption, and radioactive decay. Individual maximum contaminant levels have not been established for plutonium-238, plutonium-239, plutonium-240, and americium-241. However, these radionuclides have not been detected above the established limits for gross alpha particle activity or the proposed adjusted gross alpha activity maximum contaminant levels for drinking water. Extremely low concentrations of iodine-129 and tritium have migrated offsite, but both concentrations are well below the current U.S. Environmental Protection Agency's maximum contaminant levels for drinking water.

Of the nonradioactive metals, only total chromium has exceeded maximum contaminant levels established by the Safe Drinking Water Act. Nitrates have exceeded the maximum contaminant levels in the past near the Idaho Chemical Processing Plant but have been below the maximum contaminant level since 1988. Carbon tetrachloride, chloroform, 1,1-dichloroethylene, cis-1,2-dichloroethylene, trans-1,2-dichloroethylene, tetrachloroethylene, trichlorethylene, and vinyl chloride have exceeded maximum contaminant levels at various times over the last 5 years.

Groundwater use on the Snake River Plain includes irrigation, food processing and aquaculture, and domestic, rural, public, and livestock supply. Water use for the upper Snake River drainage basin and the Snake River Plain Aquifer was 16.4 109 cubic meters (4.3 1012 gallons) per year in 1985. Most of this water is for agriculture. The aquifer is the source of all water used at the Idaho National Engineering Laboratory. Site activities withdraw an average of 7.4 million cubic meters (1.9 billion gallons) per year, with a substantial portion discharged to the surface or subsurface and eventually returned to the aquifer. This withdrawal represents approximately 0.4 percent of the water consumed from the Eastern Snake River Plain Aquifer, or 53 percent of the maximum yield of a single typical irrigation well.

Total consumption of water at the Idaho National Engineering Laboratory averages 0.25 cubic meters per second (8.8 cubic feet per second). DOE holds a Federal Reserved Water Right for the Idaho National Engineering Laboratory, which permits a groundwater pumping capacity of 2.3 cubic meters per second (80 cubic feet per second), though this capacity is not utilized. The DOE priority on water rights dates back to the establishment of the Idaho National Engineering Laboratory.

Localized flooding can occur at the Idaho National Engineering Laboratory when the ground is frozen and melting snow combines with heavy spring rains. Test Area North was flooded in 1969; and, also in 1969, extensive flooding caused by snowmelt occurred in the lower Birch Creek Valley. Studies have shown that both the 25- and 100-year, 24-hour rainfall/snowmelt storm event could cause flooding within the Radioactive Waste Management Complex. The drainage system, including dikes and erosion prevention features designed to mitigate potential surface water flooding, have been upgraded. The area inundated by a probable maximum flood in the vicinity of Mackay Dam, 75 kilometers (45 miles) northeast of the Idaho National Engineering Laboratory, coupled with a dam failure, probably exceeds the areas expected to be inundated by 100- and 500-year floods of the Big Lost River at the Idaho National Engineering

Laboratory.

Analyses indicate that the shallow depths and low flow velocities resulting from the Mackay probable maximum flood and dam failure would not have a significant impact on Idaho National Engineering Laboratory facilities.

Onsite vegetation is predominantly shrub-steppe. Communities range from shadscale-steppe vegetation at lower altitudes, through sagebrush and grass dominated communities, to juniper woodlands along the foothills of nearby mountains and buttes. Big sagebrush and rabbitbrush are the most common shrub species. Indian ricegrass, wheatgrasses, squirreltail, and cheatgrass are common grasses. Common forbs include phlox, mustards, and Russian thistle.

About 270 vertebrate species have been observed onsite. These include 46 mammal, 204 bird, 10 reptile, 2 amphibian, and 9 fish species. Major fur-bearing species include coyote, badger, and bobcat. Important big-game species include the pronghorn, mule deer, and elk. Two federally endangered and nine candidate animal species potentially occur on the Idaho National Engineering Laboratory. The bald eagle is a winter resident and is locally common in the far north end and the western edge of the Idaho National Engineering Laboratory. Peregrine falcons are infrequently observed in the winter. Neither species is known to nest onsite, and neither is commonly observed near facilities. The candidate species include the white-faced ibis, northern goshawk, ferruginous hawk, burrowing owl, Townsend's big-eared bat, pygmy rabbit, long-eared myotis, small-footed myotis, and Idaho pointheaded grasshopper (occurs just north of the Idaho National Engineering Laboratory).

No Federal- or state-listed plant species occur at the Idaho National Engineering Laboratory, but eight plant species identified by the U.S. Bureau of Land Management, the U.S. Forest Service, or the Idaho Native Plant Society as sensitive, rare, or unique are known to occur there. These species are not generally located near any facilities and are uncommon on the Idaho National Engineering Laboratory because they require unique microhabitats.

Two interstate highways serve the general region: Interstate 15, a north-south route that connects several cities along the Snake River, approximately 40 kilometers (25 miles) east of the Idaho National Engineering Laboratory, and Interstate 86, an east-west route that intersects Interstate 15 about 64 kilometers (40 miles) south of the Idaho National Engineering Laboratory. U.S. Highways 20 and 26 are the main access routes to the southern portion of the Idaho National Engineering Laboratory. State Route 33 provides access to the northern portion of the Idaho National Engineering Laboratory from the east, State Routes 28 and 33 from the north, and State Route 22 from the west. These roads are complemented by an onsite (controlled access) system of about 140 kilometers (87 miles) of roads.

The Union Pacific Railroad provides rail service to the Idaho National Engineering Laboratory. Idaho Falls receives railroad freight service from Butte, Montana, to the north, and from Pocatello, Idaho, and Salt Lake City, Utah, to the south. The Union Pacific's Blackfoot-to-Arco route, which crosses the southern portion of the Idaho National Engineering Laboratory, provides rail service to the Idaho National Engineering Laboratory. This branch connects with a DOE spur line that links with developed areas. Most naval reactor SNF has been transported to the Idaho National Engineering Laboratory over these rail lines. Other shipments arrive by truck.

Several airlines provide Idaho Falls with aircraft passenger and cargo service.

Recorded doses from 1987 to 1991 were used as a baseline for comparison with SNF management operations for the next 40 years. The average annual occupational dose to individuals with measurable doses was 0.156 rem (156 millirem), giving an average collective dose of about 300 person-rem.

Industrial health and safety statistics from 1987 to 1991 are used as a baseline for comparison for the alternatives. There were 1,337 total recordable injury and illness cases at the Idaho National Engineering Laboratory from 1987 to 1991, for an average of 8,385 employees working a total of 79,654,000 hours. One fatality occurred at the Idaho National Engineering Laboratory between 1987 and 1991 when an employee was struck and killed by a forklift.

The water supply for the Idaho National Engineering Laboratory is provided by a system of about 30 wells, with pumps and storage tanks. The average combined pumpage from the Idaho National Engineering Laboratory wells from 1987 through 1991 was 7.4 billion liters per year (1.9 billion gallons per year), calculated based on the cumulative volumes of water withdrawn from the wells.

Average annual wastewater discharge volume at the Idaho National Engineering Laboratory for 1989 through 1991 was 537 million liters (142 million gallons).

The rated capacity of the Idaho National Engineering Laboratory electric power transmission loop line is 124 megavolt-amperes. The peak demand on the system from 1990 through 1993 was about 40 megavolt-amperes, and the average usage was approximately 200,000 megawatt-hours per year.

No high-level liquid waste resulting from reprocessing activities has been generated at the Idaho National Engineering Laboratory since 1992; however, certain other processes generate waste classified and handled as high-level waste. These sources are estimated to generate 750 cubic meters in 1995. From 1989 through 1992, an average of approximately 48.5 cubic meters of mixed low-level waste was generated annually. From 1989 through 1992, an average of approximately 46.5 cubic meters of low-level waste was generated annually.

Burial of transuranic waste ended in 1970; since then all transuranic waste has been placed in retrievable storage. Receipt of offsite transuranic waste ended in 1988 (with minor case-by-case exceptions). After 1988, only minor amounts of transuranic waste have been generated onsite and placed into retrievable storage. About 127,000 cubic meters (166,000 cubic yards) are retrievably stored or buried at the Idaho National Engineering Laboratory. The average annual volume of hazardous waste transported offsite from 1988 through 1991 was approximately 180 cubic meters. The average annual volume of industrial and commercial solid waste disposed of at the Central Facilities Area landfill from 1988 through 1992 was approximately 52,000 cubic meters (68,000 cubic yards).

4.3 Savannah River Site

This section presents summary environmental characterization information on the Savannah River Site. This information has been used to evaluate impacts at the site under various alternatives for management of SNF. More detailed information characterizing the Savannah River Site is presented in Appendix C, under separate cover.

The Atomic Energy Commission established the Savannah River Site in 1950 as the Savannah River Project to produce nuclear materials for the national defense. The number of Savannah River Site facilities grew to include five nuclear production reactors (now inactive), two chemical separations areas, a fuel and target fabrication facility (inactive), and support facilities.

The Savannah River Site occupies an area of approximately 800 square kilometers (310 square miles) in western South Carolina, in a generally rural area about 40 kilometers (25 miles) southeast of Augusta, Georgia (see Figure 4-3). The Savannah River Site, which is bordered by the Savannah River to the southwest, includes portions of three South Carolina counties: Aiken, Barnwell, and Allendale.

Approximately 73,500 hectares (181,500 acres) of the Savannah River Site is undeveloped, and 90 percent of this area (more than 65,000 hectares) is forest land. The Savannah River Forest Station (a branch of the U.S. Forest Service) manages the forested areas, many of which are pine plantations, under a cooperative agreement with DOE. Facilities that previously produced defense nuclear materials occupy approximately 5 percent of the total Savannah River Site land area. The remaining area consists of wetlands, ponds, and reservoirs.

Approximately 90 percent of the Savannah River Site work force lives in six counties around the

Savannah River Site (Aiken, Allendale, Bamberg, and Barnwell counties in South Carolina and Richmond and Columbia counties in Georgia). In 1990, employment at the Savannah River Site was 20,230, representing approximately 10 percent of the employment in the six-county region of influence. Employment at the Savannah River Site grew to 23,351 in Fiscal Year 1992, with a payroll of more than $1.1 billion. The total number of jobs at the Savannah River Site is projected to decrease to approximately 15,800 in Fiscal Year 1995.

Between 1980 and 1990, the population in the six-county region of influence increased 13 percent, from 376,058 to 425,607. More than 88 percent of the 1990 population lived in Aiken (120,940), Columbia (66,031), and Richmond (189,719) counties. According to census data, the estimated average number of persons per household in the six-county region was 2.72, and the median age of the population was 31.2 years.

The population within 80 kilometers (50 miles) of the Savannah River Site has been characterized for the purposes of identifying whether any disproportionately high and adverse impacts exist to minority and low-income communities. The population surrounding the Savannah River Site is shown to be 38 percent minority and 17 percent low-income based on U.S. Bureau of Census information, and the definitions and approach presented in Appendix L.

As of the end of Fiscal Year 1992, archaeological surveys have covered about 60 percent of the Savannah River Site and recorded 858 archaeological sites. Of these 858 sites, more than 200 have been evaluated, and 53 have been determined to be eligible for the National Register of Historic Places.

Three Native American groups-the Yuchi Tribal Organization, the National Council of Muskogee Creek, and the Indian Peoples Muskogee Tribal Town Confederacy-have expressed concern over sites and items of religious significance on the Savannah River Site. DOE routinely notifies these organizations about major planned actions on the Savannah River Site and asks them to comment on the Savannah River Site documents prepared in accordance with the National Environmental Policy Act of 1969.

Figure 4-3. Savannah River Site location and site map.

The Savannah River Site has gently rolling terrain and is heavily wooded. Facilities are scattered about the Savannah River Site, but major production facilities (for example, reactors and separations areas) are confined to its interior. As a result, the Savannah River Site facilities are generally not visible from outside of the Savannah River Site.

The Savannah River Site lies in the Coastal Plain physiographic province of South Carolina, approximately 32 kilometers (20 miles) southeast of the Fall Line, which separates the Atlantic Coastal Plain province from the Piedmont province. Onsite elevations range from 27 to 128 meters (89 to 420 feet) above mean sea level.

The Coastal Plain sediments underlying the Savannah River Site consist of sandy clays and clayey sands; however, occasional beds of clean sand, gravel, clay, and carbonate do occur. Underlying these sediments are dense crystalline igneous and metamorphic rock or younger consolidated sediments of the Triassic Period. A regional aquitard, the Appleton Confining System, hydrologically separates the Triassic formations and older igneous and metamorphic rocks from the overlying Coastal Plain sediments.

The area of the Savannah River Site is historically of low-to-moderate seismicity. On a scale of 0 to 4, the Savannah River Site is in a Uniform Building Code Seismic Risk Zone 2A. The partially mapped Pen Branch Fault, which spans the central portion of the Savannah River Site, is considered to be Cretaceous/Tertiary (140 million to 1.6 million years) reactivation of a northern boundary fault of the Triassic age Dunbarton basin. There is no evidence to indicate that the Pen Branch Fault is a capable fault as defined by the U.S. Nuclear Regulatory Commission. Surface mapping, subsurface boring, and geophysical investigations have not identified any faulting of the sedimentary strata at the Savannah River Site that would have an effect on facilities.

The closest offsite fault system of significance is the Augusta Fault Zone, approximately

40 kilometers (25 miles) from the Savannah River Site. In this fault zone, the Belair Fault has experienced the most recent movement, but it is not considered capable of generating major earthquakes. There is no conclusive evidence of recent displacement along any fault within 320 kilometers (200 miles) of the Savannah River Site, with the possible exception of the buried faults in the epicentral area of the 1886 Charleston, South Carolina, earthquake, approximately 145 kilometers (90 miles) away.

Two major earthquakes have occurred within 320 kilometers (200 miles) of the Savannah River Site: (a) the Charleston earthquake of 1886, which had an estimated Richter scale magnitude of 6.8, and (b) the Union County, South Carolina, earthquake of 1913, with an estimated Richter magnitude of 6.0, which occurred about 160 kilometers (100 miles) from the Savannah River Site. In June 1985, a minor earthquake with a local Richter scale magnitude of 2.6 and a focal depth of 1.0 kilometer (0.60 mile) occurred at the Savannah River Site. An earthquake with a local Richter scale magnitude of 2.0 occurred on the Savannah River Site on August 5, 1988, but was not felt by onsite workers.

The Savannah River Site is in a temperate region with mild winters and long humid summers. Average monthly temperatures range from 7.2C (45F) in January to 27.2C (81F) in July. The average annual precipitation at the Savannah River Site is approximately 122 centimeters (48 inches).

Prevailing winds are from the northeast and southwest, with an annual average windspeed of 3.8 meters per second (8.5 miles per hour). Windspeeds are typically highest in winter and lowest in summer.

On average, thunderstorms occur 56 days per year. The estimated probability of a tornado striking the Savannah River Site is 7.0 10-5 per year. Nine tornadoes have been confirmed on the Savannah River Site since 1953. Hurricane-strength winds have been recorded once at the Savannah River Site, from Hurricane Gracie in 1959.

Air quality at the Savannah River Site is generally good, meeting National Ambient Air Quality Standards for criteria pollutants. The nearest Class I Area, the Congaree National Monument, is more than 80 kilometers (50 miles) from the Savannah River Site. Tritium is the only radionuclide of Savannah River Site origin that is routinely detected in offsite air samples in concentrations above background.

Five streams drain the Savannah River Site: Upper Three Runs Creek, Fourmile Branch, Pen Branch, Steel Creek, and Lower Three Runs Creek. These streams originate on the Aiken Plateau and descend 15 to 60 meters (50 to 200 feet) before discharging to the Savannah River.

Surface-water quality in the Savannah River downstream of the Savannah River Site is generally good. In 1992, the South Carolina Department of Health and Environmental Control changed the classification of the river and its tributary streams to "freshwaters" from "Class B waters," imposing more stringent water quality standards. Two elements-iron and manganese (both naturally high constituents of local waters)-have historically exceeded maximum concentration limits.

Two distinct hydrogeologic systems underlie the Savannah River Site: (a) the southeastern Coastal Plain province, where a wedge of unconsolidated sediments of Late Cretaceous and Tertiary origin contains the major aquifer systems of the area, and (b) the Piedmont Province, where groundwater occurs in mudstones and sandstones within Paleozoic metamorphic and igneous basement rock. The vadose zone ranges in thickness from approximately 40 meters (130 feet) in the northernmost portion of the Savannah River Site to the surface in areas where the water table intersects wetlands or streams.

The sediments of the southeastern Coastal Plain hydrogeologic province are grouped into three major aquifer systems divided by two major confining systems, all underlain by the Appleton Confining System. These aquifer systems are known regionally as the Floridan, the Dublin, and the Midville systems. The local aquifers associated with these three aquifer systems are the Steed Pond, Crouch Branch, and McQueen Branch Aquifers.

The Crouch Branch and McQueen Branch hydrostratigraphic units are the most important aquifers in the vicinity of the Savannah River Site. The McQueen Branch Aquifer, in particular, is highly transmissive and serves as the main production aquifer for the Savannah River Site. The groundwater in the Crouch Branch and McQueen Branch Aquifers is suitable for most domestic and industrial purposes.

Industrial solvents, metals, tritium, or other constituents used or generated at the Savannah River Site have contaminated the groundwater over 5 to 10 percent of the Site. Contaminated groundwater generally underlies only a few facilities, and the contaminants detected reflect the material and processes used in these facilities. Contamination of groundwater in an aquifer supplying drinking water has occurred in one relatively small area in the northwest portion of the Savannah River Site: two wells in the Dublin-Midville Aquifer System (formerly known as the Tuscaloosa Formation) contain low concentrations of trichloroethylene and tetrachloroethylene.

The aquifers underlying the Savannah River Site sustain single-well yields of about 10.2 million liters per day (2.7 million gallons per day). The Savannah River Site withdraws approximately 14.0 billion liters per year (3.7 billion gallons per year) of groundwater for domestic and industrial uses. The Savannah River Site draws approximately 75.7 billion liters per year (20 billion gallons per year) of cooling water from the Savannah River. Water rights are not at issue at the Savannah River Site.

The Savannah River Site lies in the Upper Coastal Plain physiographic province. The Savannah River Site is near the transition area between the oak-hickory-pine forest and the southern mixed forest. As a consequence, species typical of both associations are present.

Plant communities adapted to dry conditions occur on more northern, upland areas of the Savannah River Site. (This area is sometimes referred to as the Aiken Plateau.) The most common community types on the northern half of the Savannah River Site are longleaf pine plantations and longleaf pine-turkey oak sandhills. Wetter areas along streams support different groups of plant species, including loblolly pine and bottomland hardwood forest communities. Other aquatic habitats, such as ponds, marshes, river swamps, and Carolina bays, add considerable botanical diversity to the Savannah River Site.

Four federally listed endangered animal species occur on the Savannah River Site or in the Savannah River upstream and downstream of the Savannah River Site: the red-cockaded woodpecker, the wood stork, the southern bald eagle, and the shortnose sturgeon. The U.S. Fish and Wildlife Service lists a fifth species, the American alligator, as "threatened due to similarity of appearance" (to the endangered American crocodile). Researchers have found one federally listed endangered plant species, the smooth coneflower, on the Savannah River Site.

In 1992, the Savannah River Site hunters (chosen by lottery from a large pool of applicants) harvested 1,519 deer and 168 feral hogs. The purpose of these hunts is to keep deer and feral hog populations in check and to reduce the number of animal-vehicle accidents on the Savannah River Site. The Savannah River Site measures each animal killed during the hunts for radioactivity. The maximum measurement of cesium-137 in a Savannah River Site deer was 22.4 picocuries per gram; the average was 6.4 picocuries per gram. For hogs, the maximum value was 22.9 picocuries per gram: and the average was 3.5 picocuries per gram. The estimated maximum dose received by a Savannah River Site hunter was 0.049 rem (49 millirem) per year. This estimate assumed a hunter whose entire meat consumption for the year consisted of the Savannah River Site deer.

The major sources of noise at the Savannah River Site are equipment and machinery (for example, cooling towers, transformers, engines, pumps, boilers, steam vents, and paging systems) in developed operational areas. Studies indicate that, because of the remote locations of the Savannah River Site operational areas, existing onsite noise sources do not adversely affect individuals offsite. Workplace noise limits established by the Occupational Safety and Health Administration protect onsite workers.

Interstate 20 is the primary east-west corridor in the general area of the Savannah River Site. U.S. Highways 1 and 25 are the principal north-south routes. Direct access to the Savannah River Site from the northwest is provided by South Carolina Highways 125 and 19; South Carolina Highway 125 is open to through traffic. South Carolina Highways 39 and 64 also provide access to the Savannah River Site. The

CSX railroad line also serves the Savannah River Site.

Atmospheric releases of radioactive material to the environment from Savannah River Site operations from 1990 to 1992 resulted in an average dose of approximately 0.00002 rem (0.02 millirem) per year to individuals living within an 80-kilometer (50-mile) radius of the Savannah River Site. The collective dose equivalent due to atmospheric releases from the 1992 Savannah River Site operations to the population of 620,100 occupying the 80-kilometer (50-mile) radius was 6.4 person-rem. Atmospheric releases of tritium accounted for more than 90 percent of the estimated offsite population dose.

Similarly, liquid releases of tritium account for more than 99 percent of the total radioactivity discharged to the Savannah River from the Savannah River Site activities. The calculated average annual dose to the maximum exposed individual resulting from liquid releases from 1990 to 1992 was 0.00021 rem (0.21 millirem). This resulted in average doses of 0.00004 and 0.00005 rem (0.04 and 0.05 millirem) per year to consumers of drinking water from the downstream Beaufort-Jasper (South Carolina) and Port Wentworth (Georgia) water treatment plants, respectively.

The Savannah River Site purchases power from South Carolina Electric and Gas Company through three purchased power-line interconnects to the Savannah River Site transmission grid. Recent total annual power consumption for the Savannah River Site was approximately 659,000 megawatt hours. The average load was 75 megavolt-amperes, and the peak demand was about 130 megavolt-amperes.

Average annual wastewater discharge volume at the Savannah River Site is about 2 million liters per day (528,400 gallons per day), which is about 50 percent of capacity. Eighteen waste treatment plants currently process all Savannah River Site sanitary waste. A new centralized sanitary wastewater treatment facility, scheduled for completion in mid-1995, will replace 14 of these plants.

The Savannah River Site had 127.9 million liters (33.8 million gallons) of radioactive high-level waste onsite at the end of 1991, in 50 underground tanks, which is more than 90 percent of existing capacity. By 1993, the Savannah River Site had 9,900 cubic meters (350,000 cubic feet) of transuranic waste in storage. The current volume of mixed low-level waste at the Savannah River Site is 1,700 cubic meters (60,000 cubic feet). Low-level waste is packaged for disposal onsite in carbon steel boxes and deposited in trenches. Hazardous wastes in storage at the Savannah River Site total some 1.6 million kilograms (3.6 million pounds), with a volume of 2,430 cubic meters (86,000 cubic feet).

4.4 Nevada Test Site

This section presents summary environmental characterization information on the Nevada Test Site. This information has been used to evaluate impacts at the Nevada Test Site under various alternatives for management of SNF. More detailed information characterizing the Nevada Test Site is presented in Appendix F, under separate cover.

The Nevada Test Site is located in southwestern Nevada in southern Nye County. The Nevada Test Site is bordered on three sides by the Nellis Air Force Base Bombing and Gunnery Range (see Figure 4-4). The Nellis Range serves as a buffer zone between Nevada Test Site test areas and land open to the public. The Nevada Test Site comprises about 3,500 square kilometers (1,350 square miles), making this one of the largest contiguous, unpopulated land areas in the United States. The Nevada Test Site has been used for underground weapons testing and as a nonnuclear test area. Congress has mandated that the Federal Government pursue the development of mined geologic repositories for the permanent disposal of SNF and high-level waste and has directed DOE to study the Yucca Mountain, Nevada, site to determine whether it is a suitable site for the nation's first geologic repository.

Figure 4-4. Nevada Test Site location and site map.

The majority of the land near the Nevada Test Site is managed by the U.S. Bureau of Land Management and used for livestock grazing. The area is surrounded by recreational areas used for activities such as hunting, fishing, and camping.

The economy of the two-county area near the Nevada Test Site is dominated by support services for contractor personnel at the Nevada Test Site, with a direct link to Clark County and the Las Vegas area where most of the employees reside. Most of the offsite supporting contractors and the labor and capital supporting indirect economic activity connected to the Nevada Test Site are also located in Clark County. In 1990, the population of the Las Vegas Metropolitan Statistical area was 735,000, with a 4.7 percent annual growth rate since 1980. In contrast, Nye County is sparsely populated, with employment provided by service industries, some mining, and Government-sector jobs. As of January 1994, the work force totaled 8,563.

The population within 80 kilometers (50 miles) of the Nevada Test Site has been characterized for the purposes of identifying whether any disproportionately high and adverse impacts exist to minority and low-income communities. The population surrounding the Nevada Test Site is shown to be 6 percent minority and 12 percent low-income, based on U.S. Bureau of Census information and the definitions and approach presented in Appendix L.

On the Nevada Test Site, numerous prehistoric sites and prehistoric/historic sites have been recorded and recommended as eligible for the National Register of Historic Places. However, none of them are located in the vicinity of the proposed SNF management facility. Historic activities began in 1849 with the Emigrant Trail, mining camps, and later the settlements of Bullfrog-Goldfield, Las Vegas, and Tonopah. Southern Nevada, including parts of what is now the Nevada Test Site, was inhabited by peoples of the Southern Paiute and Shoshone Tribes. Areas in the northern portion of the Nevada Test Site, including the Pahute and Rainier Mesas, contain sites of cultural affiliation to these peoples. However, no known Native American resources are located within the areas proposed for SNF facilities. Some late Pleistocene terrestrial vertebrate fossils also occur in the area, notably at Tule Springs.

The Nevada Test Site is in a visual setting of low-lying valleys and flats interspersed with mountains and the vegetation of the Mojave Desert and Great Basin. Because the public can be expected to have little concern about changes in the area's landscape and views are not regionally unique, the area may be considered to have low to moderate visual sensitivity.

The Nevada Test Site is located in the southern part of the Great Basin section of the Basin and Range Physiographic Province. Local geology is characterized by mountains of Precambrian and Paleozoic sedimentary rocks and Tertiary volcanic tuffs and lavas separated by alluvial, topographically closed valleys. Sedimentary rocks are complex, folded, and faulted carbonates in the upper and lower parts and shale and sandstone in the middle section. Volcanic rocks are predominantly Tertiary tuffs with some basalts and scattered granitic plutons. Potential geologic resources within the Nevada Test Site boundaries include silver, gold, tungsten, molybdenum, zeolites, barite, and fluorite.

The area of the Nevada Test Site is historically of low-to-moderate seismicity. On a scale of 0 to 4, the Nevada Test Site is in Uniform Building Code Seismic Risk Zones 2B and 3. Seismic activity in the Nevada Test Site area generally occurs as thrust faults, normal faults, and strike-slip faults. Recent displacements are thought to have occurred as a consequence of underground nuclear explosions. Recorded seismic activity before 1978 within 10 kilometers (6 miles) of Yucca Mountain shows seven earthquakes; two had magnitudes 3.6 and 3.4 on the Richter scale, and five had magnitudes that were smaller or could not be determined because of instrument problems. Two historical earthquakes with a magnitude of 6 (Richter scale) have been reported 110 kilometers (68 miles) southwest of Yucca Mountain and 210 kilometers (130 miles) to the northeast. Most earthquakes in the area are less than 10 kilometers (6.2 miles) in depth. Historic seismic events and the length of active faults can be used to infer a maximum magnitude of 7 to 8 for earthquakes in the Yucca Mountain region. Recurrence intervals for earthquakes with magnitudes greater than 7 are 25,000 years, greater than 6 are 2,500 years, and greater than 5 are 250 years.

The climate in the Nevada Test Site region is characterized by high solar radiation, limited precipitation, low humidity, and large diurnal temperature ranges. At Area 6, the mean daily minimum and maximum temperatures are -6.1 to 10.6C (21 to 51F) in January and 14 to 36C (57 to 96F) in July. Average precipitation at Area 6 is 15 centimeters (6 inches).

DOE maintains an extensive network of air sampling stations for radiological parameters such as particulates, reactive gases, tritium, and noble gases. Nonradiological air pollutants are within state and Federal standards. In recent years, the majority of radioactive effluents at the Nevada Test Site have resulted from underground nuclear tests. In addition, some of the radioactivity detected by onsite air monitors can be attributed to resuspension of radioactive particulate matter remaining from the atmospheric testing conducted from 1951 to 1962. Monitoring of airborne particulates, noble gases, and tritiated water vapor on the Nevada Test Site in 1992 indicated onsite concentrations that were generally not statistically different from background concentrations. External gamma exposure monitoring has indicated that the gamma environment has been consistent from year to year. Although airborne releases of radioactivity to offsite areas occurred during the years that atmospheric testing was performed, in recent years, no Nevada Test Site-related radioactivity has been detected offsite at any air sampling station.

Surface drainage in the Nevada Test Site area is ephemeral, and almost no streamflow data have been collected. Perennial surface waters occur as springs and in short reaches of the Amargosa River. Potential evaporation is 152 to 170 centimeters per year (60 to 67 inches per year). Run-off still occurs in response to infrequent storm events, which may cause local flooding, especially in Fortymile Canyon, the Amargosa River, and Jackass Flats drainage. There is the potential for a 100-year magnitude flood to transport radioactive contaminants released as a result of historic underground nuclear testing beyond the boundaries of the Nevada Test Site.

Six major aquifers occur in the area of the Nevada Test Site, including some perched groundwater. The hydrogeology is characterized by great depths to the groundwater table of 200 to 500 meters (660 to 1,640 feet) and slow velocity in the saturated and unsaturated zones. Flow velocities in these systems range from 1.8 to 183 meters (6 to 600 feet) per year. Regional groundwater flow is from the north and northeast toward the regional discharge area near Ash Meadows in the Amargosa Desert. Modeling studies for the Radioactive Waste Management Site at Area 5 indicate that the travel time from the surface to the regional water table is on the order of thousands of years.

Water in southern Nevada (excluding the Las Vegas area) is used chiefly for irrigation and to a lesser extent for livestock, municipal needs, and domestic supplies. Almost all water supplies are pumped from the groundwater aquifers, although some springs supply water to Death Valley and other areas south of the Nevada Test Site. The Nevada Test Site obtains its water supply from the aquifers underlying the Nevada Test Site in the Ash Meadows Subbasin and Alkali Flat-Furnace Creek Ranch Subbasin. Nevada Test Site water use is discussed in detail in Appendix F of Volume 1.

Groundwater meets U.S. Environmental Protection Agency secondary standards for major cations and anions and the primary standards for deleterious constituents. Contamination by radionuclides occurs below the water table as well as in the unsaturated zone above it as a result of underground nuclear testing. The extent of this contamination is currently being studied.

The Nevada Test Site lies in a transition area between the Mojave Desert and Great Basin, supporting flora and fauna from both areas. Less than 1 percent of the area has been developed. Natural vegetation occurs in nine plant communities identified as creosote bush; blackbrush; creosote-blackbrush, hopsage-desert thorn; sagebrush; saltbush; mountains, hills, and mesas; and two distinct desert thorn plant communities. Introduced weedy species, such as cheatgrass and Russian thistle, are common in disturbed areas.

Approximately 273 vertebrate wildlife species have been observed onsite, including over 30 species of reptiles, 190 species of birds, and 50 species of mammals. Common species include reptiles, rodents, raptors, and wild horses. A number of game and fur-bearing species are found on the Nevada Test Site, but hunting and trapping are not permitted.

National Wetland Inventory maps of the Nevada Test Site have not been prepared, nor have wetlands been delineated onsite. Available information indicates that wetlands on the Nevada Test Site are limited in distribution and extent. Small riverine and palustrine wetlands may occur adjacent to surface drainages, springs, playas, and reservoirs on the Nevada Test Site. There are no perennial streams on the Nevada Test Site, and permanent surface water sources are limited to a few small springs and reservoirs. Springs do not support fish populations onsite, while reservoirs support introduced bluegill, goldfish, and golden shiner.

Twenty-five federally and state-listed threatened, endangered, and other special status species have been identified on and in the vicinity of the Nevada Test Site, including 9 birds, 2 reptiles, 1 fish, 2 mammals, and 11 plant species. Federally endangered species include the American peregrine falcon, bald eagle, and Devil's Hole pupfish. The federally threatened species is the desert tortoise.

The major noise sources at the Nevada Test Site occur primarily in developed operational areas and include various facilities; equipment and machines (for example, engines, pumps, boilers, steam vents, paging systems, construction equipment, and vehicles); aircraft operations; and testing. At the Nevada Test Site boundary away from most facilities, noise levels are barely distinguishable from background noise levels. Some wildlife disturbances may occur as a result of these activities.

Vehicular access to the Nevada Test Site is provided by U.S. Route 95 from the south and off-road access via State Route 375 from the northeast. No major improvements are scheduled for these segments providing immediate access to the Nevada Test Site.

The major railroad in the area is the Union Pacific, which runs through Las Vegas and is located approximately 80 kilometers (50 miles) east of the Nevada Test Site. A 15-kilometer (9-mile) railroad serves Area 25, but it does not connect with the Union Pacific line.

Background radiation exposure and releases of radionuclides to the environment from Nevada Test Site operations provide the sources of radiation exposure to people in the Nevada Test Site region. The estimated dose-equivalent during 1992 for the population within 80 kilometers (50 miles) of the Nevada Test Site was 5.2 10-3 person-rem. The average dose was 1.1 10-5 rem (1.110-2 millirem) in 1992 for a person at the Nevada Test Site boundary. This dose is well below the National Emission Standards for Hazardous Air Pollutants standard of 0.01 rem (10 millirem) per year and is a very small percentage of the background dose.

From 1988 to 1993, water use at the Nevada Test Site varied from a high of 134 liters per second (2,125 gallons per minute) in 1989 to a low of 60 liters per second (949 gallons per minute) in 1993. Significant changes in consumption are not anticipated.

From 1989 to 1993, Nevada Test Site electrical consumption ranged from 144,521 to 183,188 megawatt hours, with peak demands varying from 30.9 to 38.4 megavolt-amperes. In 1995, consumption is projected to be 176,440 megawatt hours, with a peak demand of 39.5 megavolt-amperes.

Nevada Test Site manages the following categories of waste: low-level waste, transuranic waste, hazardous waste, radioactive mixed waste, and nonhazardous waste. The Nevada Test Site does not currently manage high-level waste or SNF. Waste management activities include onsite treatment, onsite storage, onsite disposal, and preparation for appropriate offsite disposal. In addition, the Nevada Test Site uses and manages an onsite inventory of hazardous materials, including some managed in underground storage tanks.

Total nonradioactive waste generated at the Nevada Test Site in 1992 included approximately 90,000 kilograms (100 tons) of Resource Conservation and Recovery Act hazardous waste and 218,000 kilograms (240 tons) of hazardous non-Resource Conservation and Recovery Act waste.

4.5 Oak Ridge Reservation

This section presents summary environmental characterization information on the Oak Ridge Reservation. This information has been used to evaluate impacts at the Oak Ridge Reservation under various alternatives for management of SNF. More detailed information characterizing the Oak Ridge Reservation is presented in Appendix F, under separate cover.

The Oak Ridge Reservation is located on approximately 34,667 acres (140 square kilometers) of federally owned land. The reservation comprises forested lands, public lands, buffer zones and three operations areas: Y-12 Plant, Oak Ridge National Laboratories, and the K-25 Site (formerly the Oak Ridge Gaseous Diffusion Plant) (see Figure 4-5). The Oak Ridge Reservation is located within the incorporated city limits of Oak Ridge, Tennessee. Bordering land uses are predominantly rural, including residences, small farms, forest, and pasture.

Most of the industrial and commercial development, by energy-related companies in support of the Oak Ridge Reservation, has occurred in the City of Oak Ridge in Anderson and Roane counties. Regional economic linkages at the Oak Ridge Reservation occur primarily within Anderson, Knox, Roane, and Loudon counties, where most of the offsite contractors, labor, and capital are located. Employment at the Oak Ridge Reservation in 1990 was approximately 17,080 people, and it is projected to decrease to approximately 16,980 by the year 1999.

The population within 80 kilometers (50 miles) of the Oak Ridge Reservation has been characterized for the purposes of identifying whether any disproportionately high and adverse impacts exist to minority and low-income communities. The population surrounding the Oak Ridge Reservation is shown to be 6 percent minority and 16 percent low-income, based on U.S. Bureau of Census information and the definitions and approach presented in Appendix L.

There are no identified archaeological sites or historic structures on the proposed site for the SNF management facilities on the Oak Ridge Reservation. Invertebrate fossils remains are found in early Cambrian to early Mississippian aged formations underlying the Oak Ridge Reservation. In the early 1700s, the Overhill Cherokee lived in the area of the Oak Ridge Reservation. These Native Americans were forcibly moved to Oklahoma in 1838. While the Cherokee may retain cultural affiliation with their ancestral home, there are no known Native American resources on the proposed site for SNF facilities.

Figure 4-5. Oak Ridge Reservation location and site map.

Visual resources are characterized by a series of low ridges and valleys trending northeast to southwest. Deciduous and coniferous forest covers about 80 percent of the Oak Ridge Reservation. The DOE facilities are brightly lit at night, making them highly visible.

The area of the Oak Ridge Reservation is historically of low-to-moderate seismicity. On a scale of 0 to 4, the Oak Ridge Reservation is in a Uniform Building Code Seismic Risk Zone 2A. The Oak Ridge Reservation lies entirely within the western portion of the Valley and Ridge Province, near the boundary with the Cumberland Plateau. This province is characterized by numerous linear ridges and valleys. There are three regional thrust faults in the area. From 1811 to 1975, five major earthquakes have affected the Oak Ridge Reservation area, but none has been at an intensity that caused severe damage. There is no evidence of any volcanic activity in the area for more than one million years.

The climate of the region is characterized by moderate to high precipitation in all seasons, high humidity, low winds, and low diurnal temperature ranges. At Oak Ridge, mean annual precipitation was 54 inches (137 centimeters) from 1961 to 1990. Mean daily temperatures range from 2.6C (36F) in January to 24.8C (76.7F) in July. Daytime winds are usually southwesterly, while nighttime winds are northeasterly. In Tennessee, tornadoes are infrequent. The western half of the state has experienced three times as many tornadoes as the eastern half where the Oak Ridge Reservation is located. The Oak Ridge Reservation experienced a tornado from a severe thunderstorm on February 21, 1993.

A network of air monitoring stations at the Oak Ridge Reservation measures several types of uranium particulates, heavy metals, and several materials released by a Toxic Substances Control Act incinerator. The total dose of 0.0033 rem (3.3 millirem) per year to the maximally exposed individual is well within the 0.01 rem (10 millirem) per year National Emission Standards for Hazardous Air Pollutants standard. The estimated collective committed effective dose equivalent to the approximately 880,000 persons within 80 kilometers (50 miles) of the Oak Ridge Reservation was approximately 52 person-rem for 1992. This represents about 0.02 percent of the 280,000 person-rem that the surrounding population might receive from all sources of natural radiation. The Oak Ridge Reservation meets the state and Federal standards for all criteria pollutants.

The surface drainage of the Oak Ridge Reservation includes numerous creeks (such as White Oak, Poplar, and Bear Creeks) and the Clinch River, which subsequently flow to the Tennessee River. Melton Hill Dam, immediately south of the Oak Ridge Reservation, controls the flow of the Clinch River near the Oak Ridge Reservation. Average discharge from the dam was 150 cubic meters (5,300 cubic feet) per second from 1963 to 1979. The Clinch River supplies water for the Oak Ridge Reservation and for regional industrial uses.

Geologic units of the Oak Ridge Reservation comprise two hydrologic groups: (a) the Knox Aquifer, formed by the Knox Group and Maynardsville Limestone, and (b) the Oak Ridge Reservation aquitards, which include other geologic units of the area including sandstones, siltstones, and shales. The Knox Aquifer has solution conduits that store and transmit relatively large volumes of water, while the aquitards are controlled by fractures and transmit limited amounts of water. The aquifer is the primary source of sustained stream flow on the Oak Ridge Reservation. However, some flowpaths of the Knox Aquifer lead to discharge points outside the Oak Ridge Reservation boundary. Because of the abundance of surface water in the area, groundwater wells are not common. Groundwater quality is good above 300 meters (1,000 feet), but it has high total dissolved solids at depth.

Groundwater contamination has occurred in the general area of past-practice waste disposal sites, waste storage tanks, spill sites, and contaminated inactive facilities. Principal contaminants include volatile organics, nitrates, heavy metals, and radioactivity. Exact rates and extent of the contamination have not been quantified. However, data indicate that most contamination remains relatively close to the source. As an example of the maximum extent of groundwater contamination, nitrate has been detected in wells 3,000 feet (900 meters) southwest of the source. Nitrate is relatively mobile in groundwater and may therefore define the maximum horizontal migration of contamination. At Oak Ridge National Laboratory, 20 waste area groups have been identified and are being monitored for groundwater contamination. Monitoring data from each waste area group will direct further groundwater studies. At the K-25 Site, organics are the most commonly detected groundwater contaminants. Elevated levels of gross alpha and gross beta have been detected in a number of wells. Uranium and technetium-99, respectively, appear to be primarily responsible for the elevated gross alpha and gross beta levels. The metals chromium, lead, arsenic, and barium have been detected in a number of wells at concentrations exceeding drinking water standards. Elevated levels of fluoride and polychlorinated biphenyls have also been detected in some wells.

The offsite residential drinking water quality monitoring program has detected radionuclides and organics in some offsite monitoring wells; however, concentrations have been below drinking water standards. Fluoride has been detected at concentrations exceeding drinking water standards in one offsite well. The high fluoride concentration and accompanying pH are most likely from natural chemical reactions in the substrate.

The Clinch River supplies most of the water to the Oak Ridge Reservation, the City of Oak Ridge, and other cities along the river. Major surface water uses include withdrawals for industrial and public water supplies, commercial and recreational navigation, and other recreational water activities. Because of the abundance of surface water, most community and Oak Ridge Reservation water supplies come from surface supplies rather than groundwater. One supply well exists on the reservation for use as a supplemental water supply to a laboratory. Groundwater is used for some domestic, municipal, farm, irrigation, and industrial purposes. A typical well in the aquitard yields under 0.25 gallons per minute (0.02 liters per second), and in many places wells are incapable of producing enough water to support a typical household.

The Oak Ridge Reservation area was cleared by logging and agricultural practices in the past, but it is currently dominated by pine and pine hardwood, and oak hickory, as well as northern hardwood and hemlock-white pine-hardwood forest types.

Approximately 267 different vertebrate wildlife species have been recorded onsite, including 39 mammals, 169 birds, 33 reptiles, and 26 amphibians. Local habitats include wetlands, fields, pasture, and pine plantations in addition to forest. Undeveloped areas on the Oak Ridge Reservation support game and fur-bearing populations.

Wetlands have been identified on the Oak Ridge Reservation, based primarily on the National Wetland Inventory maps. Wetlands on the Oak Ridge Reservation include emergent, scrub/shrub, and forested wetland. These wetlands are located in embayments of the Melton Hill and Watts Bar Reservoir that border the reservation; along all major streams, including East Fork Poplar Creek, Bear Creek, and their tributaries; in old farm ponds; and around groundwater seeps. Commercial fishing occurs adjacent to the Oak Ridge Reservation for catfish and carp. Sport fishing for bass, catfish, and other fresh-water fish is also popular.

Forty-seven species of federally and state-listed threatened, endangered, and other special status species have been identified on and in the vicinity of the Oak Ridge Reservation, including 19 plants, 3 amphibians, 4 reptiles, 2 fish, 14 birds, and 5 mammals. Virginia spirea is a federally threatened plant species; bald eagle, peregrine falcon, gray bat, and Indiana bat are federally endangered species found in the area. The state-listed Tennessee dace has been recorded in Bear Creek and tributaries of East Fork Poplar Creek.

The major noise sources within the Oak Ridge Reservation occur primarily in developed operational areas and include facilities and equipment and machines, such as transformers, engines, pumps, boilers, and vehicles. Outside the operations area major sources of noise are vehicles and railroad operations. At the Oak Ridge Reservation boundary, away from most of these activities, noise from these sources is barely distinguishable from background noise levels. Some disturbances of wildlife may occur on the Oak Ridge Reservation as a result of operations and construction activities.

Bear Creek Valley Road provides vehicular access to the Oak Ridge Reservation. Tennessee State Routes 58, 62, 95, and 162 pass through the Oak Ridge Reservation and are open to the public. Road construction and modification are planned for segments of Bear Creek Valley Road, Scarboro Road, and State Routes 58, 62, and 95 in the near future. Interstate 40 is within 8 kilometers (5 miles) to the south. Railroad service on the Oak Ridge Reservation is provided by CSX Transportation and the Norfolk and Southern Corporation. Knoxville is the closest major airport, 64 kilometers (40 miles) away.

Low-level, hazardous, and mixed wastes are generated and managed at the Y-12 Plant, K-25 Site, and the Oak Ridge National Laboratory. Nonhazardous wastes are generated at all three sites and disposed of at the Y-12 Plant Sanitary Landfill. Oak Ridge Reservation generates and manages SNF and transuranic waste. Waste management at the Y-12 Plant and the Oak Ridge National Laboratory includes onsite waste treatment, onsite waste disposal, preparation for proper offsite waste disposal, and onsite waste storage.

Liquid and solid hazardous wastes are disposed of offsite. Some low-level radioactive wastes are disposed of onsite.

4.6 Naval Sites

This section presents summary environmental characterization information on the naval sites that have been evaluated under various alternatives for management or examination of naval SNF. This information has been used to evaluate impacts at the sites under various alternatives for management of SNF.

More detailed information characterizing these sites is presented in Appendix D, under separate cover.

The average annual radiation exposure for each naval shipyard radiation worker is 0.26 rem (260 millirem) (NNPP 1993). The average lifetime accumulated exposure for shipyard workers is 1.2 rem (1,200 millirem) (NNPP 1993).

4.6.1 Puget Sound Naval Shipyard

The Puget Sound Naval Shipyard is located in Bremerton, Washington, 23 kilometers (14 miles) west of Seattle and 32 kilometers (20 miles) northwest of Tacoma (Figure 4-6). The population within 80 kilometers (50 miles) of the shipyard is about 3 million people.

The population within 80 kilometers (50 miles) of the Puget Sound Naval Shipyard has been characterized for the purposes of identifying whether any disproportionately high and adverse impacts exist to minority and low-income communities. The population surrounding the Puget Sound Naval Shipyard is shown to be 13 percent minority and 8 percent low-income, based on U.S. Bureau of Census information and the definitions and approach presented in Appendix L.

Puget Sound Naval Shipyard is on 132 hectares (327 acres) of highly developed land. The waterfront dry dock area is the high-security portion of the shipyard where most production activities take place. This area includes production shops, administration, and some public works and supply functions.

The upland area of the shipyard provides services to military personnel, including housing, retail goods and services, recreation, counseling, dental care, and other support services. The industrial support area in the southwestern portion of the shipyard includes several piers for homeported ships and inactive fleet, the power plant, warehouses, a steel yard, public works shops, and parking.

There are about 10,200 civilians working at the shipyard. With other Government facilities in the area, the Federal payroll in Kitsap County, where the shipyard is located, provides about 45 percent of the total employment.

There are no prehistoric archaeological sites identified at the shipyard. There are four National Registered Historical Districts and one National Historic Landmark within the boundaries of the shipyard.

Until the mid-1880s, Kitsap County was inhabited by several Native American tribes of the Salish language group who lived on the shores of Puget Sound. For about

Figure 4-6. Puget Sound Naval Shipyard location and vicinity map.

100 years, the principal settlement of the Suquamish Tribe lay along the west shore of Agate Passage. There are no Native American properties or ceremonial sites in the shipyard areas where SNF activities would be conducted.

The natural topography of the shipyard has been altered significantly from its original condition.

Portions of the upland areas of the complex were cut to fill marshes and create level land. The resulting fill material was predominantly a silty, gravelly sand with occasional pockets of silts and clays. The remaining areas of natural soils vary from dense glacial deposits to soft bay mud and peat. The upland soil is a stiff, hardpacked, clay soil with low permeability.

The site lies within Uniform Building Code Seismic Risk Zone 3. There have been approximately

200 earthquakes in the area since 1840, most of which caused little or no damage. The most recent earthquakes of high magnitude were near Olympia [64 kilometers (40 miles) from Bremerton] in 1949 (7.1 on the Richter scale) and near Seattle in 1965 (6.5 on the Richter scale). The central Puget Sound area could experience an earthquake of intensity 7.5 on the Richter scale. There has been no known surface faulting in conjunction with earthquakes in the shipyard region. Potential hazards from volcanism are minimal and limited to windborne volcanic ash.

The potential hazard from tsunamis and seiches is minimal because the system of straits and inlets that surround Puget Sound provides a natural barrier, effectively damping the propagation of distantly generated tsunamis.

The general area around Bremerton is damp, cool, and cloudy much of the year. Average windspeed at the Seattle-Tacoma Airport is 4 meters per second (9 miles per hour), with prevailing winds from the southwest.

The Code of Federal Regulations (40 CFR Part 81) states that the Air Quality Control Region for this site is better than national standards for total suspended particulate matter and sulfur dioxide. The area has no specific classification for ozone, carbon monoxide, and nitrogen dioxide. The nearest Class I Area is Olympic National Park, approximately 24 kilometers (15 miles) from the site.

Puget Sound Naval Shipyard has no important surface freshwaters. Groundwater is generally found within 30 meters (100 feet) of the ground surface in sand and gravel layers. The quality of most groundwater near Bremerton is good. Groundwater is used for approximately 35 percent of the public water supply. Current shipyard use is about 2.6 billion liters (676 million gallons) annually.

Vegetation and wildlife on the Puget Sound Naval Shipyard are limited to undeveloped areas that comprise approximately 19 hectares (46 acres) of the entire Bremerton Naval Complex. Most of these areas have been previously disturbed and are currently landscaped with native and ornamental trees and shrubs. No sensitive, threatened, or endangered aquatic or terrestrial species have been observed at the shipyard.

Land access to the Seattle/Tacoma area is over two interstate highways: Interstate 90 and Interstate 5. The major thoroughfare in south Kitsap County is State Route 16, which runs south from Bremerton to Tacoma where it connects with Interstate 5. Bremerton's primary access routes include State Routes 3, 303, and 304.

The Burlington Northern Railroad provides scheduled and on-demand freight service to southern and central Kitsap County. A Navy-owned spur line from Shelton, Washington, provides additional rail service to the shipyard. SNF originating at Bremerton and Pearl Harbor has historically been transported by rail from Bremerton to the Expended Core Facility at the Idaho National Engineering Laboratory. Since 1962, all 134 shipments of SNF have been sent from Bremerton to the Idaho National Engineering Laboratory by rail-114 originating from Puget Sound Naval Shipyard and 20 transported by ship from Hawaii to the Puget Sound Naval Shipyard, where the containers were transferred to railcars for the journey to the Idaho National Engineering Laboratory.

The annual airborne emissions from the site do not result in any measurable radiation exposure to the general public. Emissions of radionuclides from the site result in a calculated effective dose equivalent of less than 0.0001 rem (0.1 millirem) per year to any member of the general public.

In addition, normal activities associated with current naval nuclear operations at the site do not result in the intentional discharge of any radioactive liquid effluent. Environmental monitoring programs conducted by the site and independent U.S. Environmental Protection Agency monitoring of shipyard sites have shown that the operations at the site have had no adverse impacts on public health or safety. Additional discussion of these monitoring programs is found in Section 4.1.1 of Appendix D of Volume 1 of this EIS.

4.6.2 Norfolk Naval Shipyard

Norfolk Naval Shipyard is located in the Tidewater region of Virginia and is contiguous with the city of Portsmouth (see Figure 4-7). Newport News Shipyard, where some naval nuclear ships are defueled, is located in Newport News, Virginia (see Figure 4-8). Six city areas are within 24 kilometers (15 miles) of the Norfolk Naval Shipyard: Portsmouth, Chesapeake, Norfolk, Virginia Beach, Hampton and Newport News, and Suffolk. About 1.5 million people (USBC 1992) reside within an 80-kilometer (50-mile) radius of the shipyard, and about 8,500 shipyard workers are employed at the shipyard.

The population within 80 kilometers (50 miles) of the Norfolk Naval Shipyard has been characterized for the purposes of identifying whether any disproportionately high and adverse impacts exist to minority and low-income communities. The population surrounding the Norfolk Naval Shipyard is shown to be 33 percent minority and 11 percent low-income, based on U.S. Bureau of Census information and the definitions and approach presented in Appendix L.

Figure 4-7. Norfolk Naval Shipyard location and vicinity map.Figure 4-8. Newport News Shipyard location and vicinity map.

Norfolk Naval Shipyard occupies over 486 hectares (1,200 acres) and includes over 500 administrative, industrial, and support structures along 4 miles of shoreline. Over 95 percent of the land within its boundaries is covered with structures or paved with concrete or asphalt. The facility is divided into a controlled industrial area and a nonindustrial area. All piers, dry docks, and work facilities involved with naval nuclear propulsion plant work are within the controlled industrial area.

No prehistoric archaeological sites or submerged cultural resources have been identified at the shipyard. Drydock I is a National Historic Landmark. There are no Native American properties or ceremonial sites in the areas where naval SNF activities would be conducted.

Norfolk Naval Shipyard is located in Uniform Building Code Seismic Risk Zone 1, which is the second lowest of four risk categories. No volcanic hazards exist.

The general climate of the area is mild and moist, with predominant winds from the south to southwest. In summer, afternoon thunderstorms are very common. Thunderstorms occasionally spawn isolated tornadoes throughout the region, but they move through the area rapidly along with storm centers. Hurricanes and tidal flooding are not uncommon; tornados are infrequent. The Code of Federal Regulations (40 CFR Part 81) states that the Air Quality Control Region that includes this site is in marginal nonattainment for ozone and is better than national standards for total suspended particulate matter and sulfur dioxide. The area has no specific classification for carbon monoxide and nitrogen dioxide. The nearest Class I Area is the Swanquarter National Wilderness Area, which is approximately 160 kilometers (100 miles) from the site.

Norfolk Naval Shipyard is located on the Southern Branch of the Elizabeth River in a highly industrialized area of the city of Portsmouth, Virginia, 13 kilometers (8 miles) upstream from the confluence of the James and Elizabeth Rivers. The Southern Branch is a deep water river that provides access to heavy industry in the vicinity of the shipyard. The Southern Branch is brackish and is not a source of drinking water.

Shallow groundwater underlies the whole region. Designated as the Columbia Aquifer, the aquifer is comprised of interbedded gravel, sand, silt, and clay and is unconfined throughout the region. Underneath the Columbia Aquifer is the Yorktown Aquifer, which is a major source of domestic, commercial, and light industrial water. This aquifer is the usual source of drinking and domestic consumption water for those localities within the region not served by municipal water systems.

The shipyard area is highly developed, and its surface is about 95 percent covered with impervious materials. Several federally designated threatened or endangered species exist in the region; however, habitats have not been identified on shipyard property. No state-listed rare, threatened, or endangered species exist within the 24-kilometer (15-mile) tidal influence zone.

There are three main road corridors within the city of Portsmouth. These roads are High Street, Portsmouth Boulevard, and George Washington Highway, and they provide access to suburban commercial and residential areas. The Downtown and Midtown Tunnels link Portsmouth and Norfolk and join via connecting arteries to the regional interstate highway network consisting of Interstates 64, 262, 464, and 664. Interstate 64 crosses Hampton Roads and Interstate 664 crosses the lower James River, linking the south-side cities to Newport News and Hampton on the peninsula.

Norfolk Southern and CSX operate extensive rail transportation networks for freight and bulk cargo. Norfolk and Newport News are the Nation's largest terminals for coal exports, and, along with Portsmouth, have a large capacity for containerized and bulk cargos. Lines operated by CSX and Norfolk Southern subsidiaries serve the shipyard at the north and south ends and at Southgate and St. Juliens Creek annexes. Since 1965, all 10 shipments of naval SNF originating at the Norfolk Naval Shipyard have been made by rail to the Expended Core Facility at the Idaho National Engineering Laboratory.

The annual airborne emissions from the site do not result in any measurable radiation exposure to the general public. Emissions of radionuclides from the site result in a calculated effective dose equivalent of less than 0.0001 rem (0.1 millirem) per year to any member of the general public.

In addition, normal activities associated with current naval nuclear operations at the site do not result in the intentional discharge of any radioactive liquid effluent. Environmental monitoring programs conducted by the site and independent U.S. Environmental Protection Agency monitoring of shipyard sites have shown that the operations at the site have had no adverse impacts on public health or safety. Additional discussion of these monitoring programs is found in Section 4.1.2 of Appendix D of Volume 1 of this EIS.

4.6.3 Portsmouth Naval Shipyard

Portsmouth Naval Shipyard is located in York County, in the southeast corner of Maine. It is on Seavey Island, near the mouth of the Piscataqua River (see Figure 4-9). Seavey Island has an area of 113 hectares (278 acres). To the north lies the low-density residential community of Kittery, Maine. South of the shipyard, across the river, is the city of Portsmouth (population 22,300) and the town of New Castle in New Hampshire. The population within an 80-kilometer (50-mile) radius of the site is approximately 2.4 million. The shipyard is the region's largest employer, with 5,000 employees.

Figure 4-9. Portsmouth Naval Shipyard location and vicinity map.

The population within 80 kilometers (50 miles) of the Portsmouth Naval Shipyard has been characterized for the purposes of identifying whether any disproportionately high and adverse impacts exist to minority and low-income communities. The population surrounding the Portsmouth Naval Shipyard is shown to be 5 percent minority and 7 percent low-income, based on U.S. Bureau of Census information and the definitions and approach presented in Appendix L.

On November 17, 1977, the National Park Service, U.S. Department of the Interior, entered the Portsmouth Naval Shipyard Historic District on the National Register of Historic Places. The district includes 54 acres of land and 59 buildings and structures. There are no known cultural resources in the area of the site where naval SNF would be stored.

Seavey Island is a rock knob, a prominent bedrock outcrop. The bedrock is a fine-grained, lime-silicate material consisting of chalky sandstone formed under heat and pressure, siltstone, and gray sandstone shale. There are no economic geologic resources at the site.

The shipyard is in Uniform Building Code Seismic Risk Zone 2A. Numerous small faults are found in rock units across the region, but only the Rye-Kittery contact is important enough to show on a geologic map.

The typical weather is caused by various incursions of cold, dry arctic air; warm land air from the Gulf States; and cool, damp air from the Atlantic Ocean. Dominance of these systems can change on a daily basis, creating highly variable weather conditions. Precipitation is evenly distributed over the year for an annual total of 108 centimeters (42.6 inches). Local fog is observed 15 percent of the time, and it is dense enough to restrict visibility to 2 kilometers (1.2 miles) or less about 35 percent of that time.

Winds average 3.9 meters per second (8.8 miles per hour), but speeds greater than 17.9 meters per second (40 miles per hour) can occur any time of year. Severe weather from tornadoes and hurricanes is rare.

The Code of Federal Regulations (40 CFR Part 81) states that the Air Quality Control Region for this site is in moderate nonattainment for ozone and is better than national standards for total suspended particulate matter and sulfur dioxide. The area has no specific classification for carbon monoxide and nitrogen dioxide. The nearest Class I Area to the site is the Presidential Range-Dry River Wilderness Area, which is approximately 120 kilometers (75 miles) from the shipyard.

The Piscataqua River, formed by the confluence of the Cocheco River and the Salmon Falls River, flows southeasterly for 21 kilometers (13 miles) until it enters the ocean at Portsmouth Harbor. The entire 21 kilometers (13 miles) of the river is tidal. The river is one of the fastest flowing tidal waterways of any commercial port in the northeastern United States. The Piscataqua River is designated as having acceptable water quality.

The limited amount of vegetation and the industrial nature of the shipyard limit the availability of suitable habitat for most terrestrial species. There is one small freshwater wetland located at the shipyard. No threatened or endangered species have been identified at the site.

Vehicles can reach the Kittery-Portsmouth area by means of Interstate 95 and U.S. Route 1. The shipyard is accessible by two federally owned bridges that cross to the residential streets of Kittery, Maine. Walker Avenue is the primary access route to Bridge 1, and Whipple Road provides direct access to Bridge 2.

There is daily freight rail service to the Shipyard by the Boston and Maine Railroad. The railroad connects Portsmouth with Manchester, New Hampshire; Portland, Maine; and Boston, Massachusetts.

Naval SNF has been removed from Navy nuclear ships at the shipyard and transported to the Idaho National Engineering Laboratory since 1959. There have been 43 shipments made, all by rail.

The annual airborne emissions from the site do not result in any measurable radiation exposure to the general public. Emissions of radionuclides from the site result in a calculated effective dose equivalent of less than 0.0001 rem (0.1 millirem) per year to any member of the general public.

In addition, normal activities associated with current naval nuclear operations at the site do not result in the intentional discharge of any radioactive liquid effluent. Environmental monitoring programs conducted by the site and independent U.S. Environmental Protection Agency monitoring of shipyard sites have shown that the operations at the site have had no adverse impacts on public health or safety. Additional discussion of these monitoring programs is found in Section 4.1.3 of Appendix D of Volume 1 of this EIS.

4.6.4 Pearl Harbor Naval Shipyard

The Pearl Harbor Naval Shipyard is located in the Southeast Loch of Pearl Harbor, Oahu, Hawaii (see Figure 4-10). The population of the island of Oahu was approximately 820,000 people in 1990.

The population within 80 kilometers (50 miles) of the Pearl Harbor Naval Shipyard has been characterized for the purposes of identifying whether any disproportionately high and adverse impacts exist to minority and low-income communities. The population surrounding the Pearl Harbor Naval Shipyard is shown to be 68 percent minority and 7 percent low-income, based on U.S. Bureau of Census information and the definitions and approach presented in Appendix L.

Figure 4-10. Pearl Harbor Naval Shipyard location and vicinity map.

The shipyard employs about 5,000 civilian employees, and, combined with other U.S. Department of Defense civilian employees, it accounts for 10,900 local jobs.

Pearl Harbor has been the site of several important historical events, and it is most noted for its role in the Pacific Theater Defense during World War II. Naval Base Pearl Harbor was designated as a National Historic Landmark in 1964; in 1974, it was listed on the National Register of Historic Places. There are no archaeological sites located within the boundary of the shipyard. There are no Native Hawaiian properties or ceremonial sites in the shipyard areas where naval SNF activities would be conducted.

Pearl Harbor estuary lies on the coastal sedimentary plain of southern Oahu. Streams, springs, and groundwater flow into the harbor. The estuary was formed by freshwater flows that have eroded the coastal plain and retarded coral growth. The west side of the harbor is primarily comprised of limestone reef material. The east side of the harbor is mainly compacted volcanic ash. Hard, dense volcanic rock forms the bulk of the rock material to the north. Much of the land area in Pearl Harbor is fill land created by dredge spoils. There are no geologic resources of economic value at the shipyard.

The Pearl Harbor Naval Shipyard is located in Uniform Building Code Seismic Risk Zone 1. Except for the island of Hawaii, the islands are not a highly seismic area. Even on Hawaii, most of the earthquakes originate from volcanic activity and do little or no damage, although a few have been quite severe. The Hawaiian Islands were formed by volcanic eruptions; however, the only active volcanic area is on the island of Hawaii. There are no volcanic hazards on the Island of Oahu.

Past tsunami inundation levels have been about 1 meter (3 feet) above mean sea level. Projected tsunami wave elevations for the 10-, 100-, and 500-year event are 0.2, 0.6, and 1.2 meters (0.8, 2.0, and 3.8 feet), respectively, for adjacent coastal areas. Maximum reasonably foreseeable typhoon storm water level rise would be approximately 4.3 meters (14.5 feet) above mean sea level.

The predominant winds are from the northeast, particularly from February to November. At certain times of the year, south to southwest winds and mild offshore breezes can be expected. Winds with speeds up to 22 meters per second (49 miles per hour) occasionally strike from the north or northeast, but they rarely reach gale velocities. Southerly winds are usually accompanied by wet tropical air and frequent heavy showers. Destructive hurricanes with high tidal surges have hit the Hawaiian Islands twice in the past 25 years (both times centered on Kauai), in 1982 and 1992.

The Code of Federal Regulations (40 CFR Part 81) states that the Air Quality Control Region for this site is better than national standards for total suspended particulate matter and sulfur dioxide. The area has no specific classification for ozone, carbon monoxide, and nitrogen dioxide. The nearest Class I Area is Haleakala National Park, on the Island of Maui, which is 188 kilometers (117 miles) from the shipyard.

Eight streams discharge into Pearl Harbor. Some flooding occurs along the major streams, but it is not a problem at the naval complex, affecting only a narrow strip along Aiea Stream. Naval Base Pearl Harbor receives most of its water from the Koolau Aquifer and a small portion from the Waianae Aquifer, which are located in south central Oahu.

No federally or state-listed threatened or endangered species or critical habitats are known to exist within the confines of the shipyard. Because the area has been greatly disturbed and native vegetation completely eliminated, there is little remaining terrestrial habitat of any consequence. Some migratory birds and indigenous waterfowl occasionally frequent the shoreline areas of the shipyard, but none are residents.

There are several wetland areas within the Pearl Harbor area, including the Pearl Harbor National Wildlife Refuge, which provides habitat for the endangered Hawaiian Coot and Hawaiian Stilt.

The traffic into and out of the base is a combination of commuting traffic, residential-related traffic, and service traffic. Kamehameha Highway is the primary access route to the base from the Ewa/ Pearl City/ central Oahu direction. Both Kamehameha Highway and Interstate Highway H-1 provide access to the Naval Base from Honolulu.

Naval SNF has been removed from Navy nuclear-powered ships and transported to the Expended Core Facility at the Idaho National Engineering Laboratory. Naval SNF shipments to the Idaho National Engineering Laboratory were initiated in 1962. Since then, 20 shipments have been made. The shipments were taken by ship to the Puget Sound Naval Shipyard, where the containers were then transported to the Idaho National Engineering Laboratory by rail.

The annual airborne emissions from the site do not result in any measurable radiation exposure to the general public. Emissions of radionuclides from the site result in a calculated effective dose equivalent of less than 0.0001 rem (0.1 millirem) per year to any member of the general public.

In addition, normal activities associated with current naval nuclear operations at the site do not result in the intentional discharge of any radioactive liquid effluent. Environmental monitoring programs conducted by the site and independent U.S. Environmental Protection Agency monitoring of shipyard sites have shown that the operations at the site have had no adverse impacts on public health or safety. Additional discussion of these monitoring programs is found in Section 4.1.1 of Appendix D of Volume 1 of this EIS.

4.6.5 Kesselring Site

The Kenneth A. Kesselring Site is located about 24 kilometers (15 miles) north of the City of Schenectady, New York, and 13 kilometers (8 miles) west of Saratoga Springs (see Figure 4-11). It contains three operating naval nuclear propulsion prototype plants and support facilities. The site also includes one prototype plant that is being permanently shut down and one prototype that has been permanently shut down. All operating facilities are located in a secure area near the center of the 1,578-hectare (3,900-acre) reservation.

In 1993, the site employed about 1,450 civilian workers. About 1.15 million people live within an 80-kilometer (50-mile radius) of the site according to the 1990 Census, but most of the land immediately adjacent to the site is either wooded or used for agriculture. The nearest cities include those previously mentioned and Gloversville, Amsterdam, and Albany.

The population within 80 kilometers (50 miles) of the Kesselring Site has been characterized for the purposes of identifying whether any disproportionately high and adverse impacts exist to minority and low-income communities. The population surrounding the Kesselring Site is shown to be 6 percent minority and 9 percent low-income, based on U.S. Bureau of Census information and the definitions and approach presented in Appendix L.

The Kesselring Site reservation was used primarily for agricultural purposes before Federal Government acquisition in 1948. There are no known archaeological, architectural, cultural, or Native American Indian sites in the secure area where SNF storage would take place.

The site lies on primarily unconsolidated material, primarily of glacial origin, that overlies bedrock. Where it exists, the overburden can be up to several hundred feet thick. The overburden consists of three basic kinds of depositional units: glacier debris, lake, and ice-contact/outwash deposits. Deposits from glaciers overlie much of the bedrock and form the elliptical hills throughout most of the reservation. The glacier deposits are a dense and poorly sorted mixture of clay, silt, sand, gravel, and boulders. Thinly stratified lake clay and silt deposits are mapped over the southeastern quadrant of the site. The ice-contact/outwash deposits mostly consist of stratified sands and gravels.

The general area of the site is in Uniform Building Code Seismic Risk Zone 2, with a moderate risk of damage caused by earthquakes. There is a Zone 1 (minor damage) area to the south and a Zone 3 (major damage) area to the north of the site. The maximum intensity earthquake within 161 kilometers (100 miles) of the site had a Modified Mercalli Intensity Scale value of VII. The most recent earthquake of that intensity occurred at Lake George, New York, on April 30, 1931. Because the site is located near the fault system that caused this quake, an earthquake of similar intensity could occur at the site. There are no volcanic hazards in the vicinity of the site.

Figure 4-11. Kesselring Site location and vicinity map.

The general climate of the site is cold in winter and cool to warm in summer. Winds originate mostly from the west or northwest during the winter, but come from the south in the warmer months. Wind velocities are moderate and generally average less than 4.5 meters per second (10 miles per hour).

Destructive winds [greater than 36 meters per second (80 miles per hour)] occur infrequently, and tornadoes are rare.

The Code of Federal Regulations (40 CFR Part 81) states that the Air Quality Control Region that includes this site is in marginal nonattainment for ozone and is better than national standards for total suspended particulate matter and sulfur dioxide. The area has no specific classification for carbon monoxide and nitrogen dioxide. The nearest Class I Area is at Lye Brook Wilderness, Suarderland, Vermont, which is 74 kilometers (46 miles) from the site.

The Kesselring Site is located in a predominately rural area. There are 13 wetlands on the Kesselring Site; current operations do not impact these wetlands. Federally or state-listed threatened and endangered species located in the Saratoga County area include the bald eagle, the karner blue butterfly, the peregrine falcon, and the red-shouldered hawk. There are, however, no records of any of these species on the site.

Only secondary roads follow the boundary of the site. They are used primarily by Kesselring Site employees and as delivery routes for small products and produce. State Route 29 runs 3 kilometers (2 miles) to the north, State Route 147 runs 6 kilometers (4 miles) to the west, and State Route 67 runs 6 kilometers (4 miles) to the south. State Route 50, 10 kilometers (6 miles) east, running from Saratoga Springs to Scotia, carries the only appreciable amount of truck and bus traffic. The majority of through traffic uses either Interstate 87 or parallel route U.S. Highway 9, 16 kilometers (10 miles) to the east.

Two lines of the Delaware and Hudson Railroad cross the region within 16 kilometers (10 miles) of the site. The main north-south line runs through Ballston Spa, just over 8 kilometers (5 miles) to the east, and a trunkline runs just over 8 kilometers (5 miles) to the northeast into the central Adirondack area.

SNF from the Kesselring Site has been sent to the Expended Core Facility at the Idaho National Engineering Laboratory since 1961. Shipping containers are transported by truck to a nearby commercial rail line where the containers were loaded onto rail cars. Since 1961, 20 shipments of naval SNF have been sent to the Expended Core Facility from the Kesselring Site.

The annual airborne emissions from the site do not result in measurable radiation exposure to the general public. Emissions of radionuclides from the site result in a calculated effective dose equivalent of less than 0.0001 rem (0.1 millirem) per year to any member of the general public.

In addition, normal activities associated with current naval nuclear operations at the site do not result in the intentional discharge of any radioactive liquid effluent. Environmental monitoring programs conducted by the site have shown that the operations at the site have had no adverse impacts on public health or safety.

4.7 Other Generator/Storage Locations

In addition to the five major sites, DOE is responsible for the management of SNF generated at several other DOE sites and other locations. These sites include DOE reactors at sites other than the Hanford Site, Idaho National Engineering Laboratory, the Savannah River Site, and the Oak Ridge Reservation; university and domestic research reactors; and three locations where specific types of commercial power reactor SNF for which DOE is responsible are stored. This section summarizes environmental characterization information for these sites that might be affected by programmatic decisions on SNF management. More detailed information characterizing the sites is presented in Appendix E, under separate cover.

The facilities and installations included in this category preclude the definition of their affected environments in a consistent and uniform manner without describing each site. The information available in existing facility documents varies widely depending on the nature of the installation and the requirements for describing the environment by the overseeing or regulatory agencies. For example, the environmental parameters required to be described by the U.S. Nuclear Regulatory Commission for licensing of small research reactors or material processing and storage facilities are fewer in number and less detailed than those required for larger reactor installations at DOE facilities. Thus, the ability to represent these environmental parameters in a consistent manner based on existing documentation is limited, and several parameters addressed for the major DOE sites are not discussed at all or are discussed only to a limited degree for many of these other generator/ storage locations. Because alternatives evaluated will not require alteration of these sites, the sites are not described in detail. See Appendix E, Chapter 4 for more information.

4.7.1 DOE Test and Experimental Reactors

In addition to facilities at the Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, and Oak Ridge Reservation, experimental reactors are located at, and small quantities of SNF are in storage at, the following four DOE sites: Brookhaven National Laboratory, Los Alamos National Laboratory, Sandia National Laboratories, and Argonne National Laboratory-East.

4.7.1.1 Brookhaven National Laboratory.

Brookhaven National Laboratory is located on a 2,131-hectare (5,265-acre) site on Long Island, New York, approximately 97 kilometers (60 miles) east of New York City, in a primarily suburban area. About 410,000 people reside in Brookhaven Township, which houses the Laboratory, and 8,000 people live within 0.8 kilometer (0.5 mile) of the Laboratory boundary.

In terms of meteorology, the laboratory can be characterized, like most Eastern Seaboard areas, as a well-ventilated site. The annual precipitation during 1991 was 45.3 inches (115 centimeters), which is about 3.1 inches (8.0 centimeters) below the 40-year annual precipitation average of 48.4 inches (123 centimeters).

Suffolk County, in which the site is located, is classified as being in nonattainment of the standards for the criteria pollutant ozone. The county is in attainment of standards for carbon monoxide, particulates, sulfur dioxide, nitrogen dioxide, and lead.

No active earthquake-producing faults are known in the Long Island area. The area lies in a Uniform Building Code Seismic Risk Zone 2A (moderate seismic hazard) area.

Groundwater flow under the Laboratory site is complex, moving in different directions in different sections of the site, but generally with a velocity estimated to range from 30 to 45 centimeters per day (12 to 18 inches per day), flowing either toward the Peconic River or in deeper layers recharging the Atlantic Ocean. The Nassau/Suffolk Aquifer System underlying the Brookhaven National Laboratory has been designated a sole source aquifer by the U.S. Environmental Protection Agency.

The releases of radioactive gaseous and liquid effluents from Brookhaven National Laboratory from 1988 to 1992 have resulted in calculated average doses to hypothetical maximally exposed individuals of 0.000113 and 0.000722 rem (0.113 and 0.722 millirem) per year, respectively.

4.7.1.2 Los Alamos National Laboratory.

Los Alamos occupies an area of about 11,000 hectares (28,000 acres) located primarily in Los Alamos county in northern New Mexico, about 39 kilometers (24 miles) northwest of Santa Fe. The resident population of Los Alamos county in 1990 was 18,115; about 3,900 Los Alamos National Laboratory employees reside in the adjacent Rio Arriba and Santa Fe counties.

The climate at Los Alamos National Laboratory is characterized as semi-arid steppe, with an average annual rainfall of about 21 centimeters (8.1 inches). Severe weather affecting facility design or operation is extremely rare. Los Alamos National Laboratory is located in the New Mexico Intrastate Air Quality Control Region. Areas in Los Alamos National Laboratory and its surrounding counties are designated as in attainment with respect to the National Ambient Air Quality Standards.

The Los Alamos National Laboratory is located on the Pajarito Plateau, which is dissected by deep canyons separated by long narrow mesas. It lies within Seismic Zone 2B, and seismic hazards studies have identified three active faults in the area. Studies suggest seismic events with a magnitude of 6.5 to 7.8 have been produced in the last 500,000 years.

Surface water at Los Alamos consists of intermittent streams; several canyons receive treated industrial or sanitary effluents that rarely extend aboveground beyond Los Alamos National Laboratory boundaries. The depth to the main groundwater aquifer, which supplies nearly all water at Los Alamos National Laboratory, ranges from about 366 meters (1,200 feet) in the west to about 183 meters (600 feet) in the east part of the site, and groundwater discharges to springs along the Rio Grande.

The releases of radioactive effluents from Los Alamos National Laboratory over the period 1987 to 1991 have resulted in a calculated average dose to the hypothetical maximally exposed individual of about 0.004 rem (4 millirem) per year.

4.7.1.3 Sandia National Laboratories.

The Sandia National Laboratories reactor and SNF operations are located on about 3,360 hectares (8,300 acres) of Kirtland Air Force Base allocated to DOE, approximately 10 kilometers (6.5 miles) southeast of downtown Albuquerque, New Mexico. The 1990 population of Albuquerque was about 385,000.

The climate at Sandia National Laboratories is characteristic of a semi-arid steppe, with an average annual rainfall of about 21 centimeters (8.1 inches). Severe weather affecting facility design or operation is extremely rare. The Sandia National Laboratories is within the Albuquerque-Mid Rio Grande New Mexico Intrastate Air Quality Control Region, portions of which are designated as nonattainment by the U.S. Environmental Protection Agency for Colorado.

The Sandia National Laboratories is located on the Albuquerque East Mesa in a Seismic Zone 2B, in a region of high seismic activity but of low magnitude and intensity. More than 1,100 earthquakes have occurred during the last 127 years, but only 3 have caused damage in Albuquerque.

The Rio Grande is the main surface drainage route for the area, with an average flow of about 28.5 cubic meters per second (37.3 cubic yards per second). No perennial streams flow through the Sandia National Laboratories area, and flooding is not a high probability at Kirtland Air Force Base. The groundwater is distinguished by a fault complex underlying the area; depths range from 15 to 30 meters (50 to 100 feet) on the east side of the complex and from 115 to 152 meters (380 to 500 feet) on the west side. Groundwater flow west of the complex is generally toward the north and northwest, and groundwater flow east of the fault complex is typically west toward the fault system.

4.7.1.4 Argonne National Laboratory-East.

Argonne National Laboratory-East occupies about a 688-hectare (1,700-acre) site located in DuPage County, Illinois, within the Chicago metropolitan area. The site is surrounded by a 826-hectare (2,040-acre) green belt forest preserve operated by DuPage County. The 1990 population of the Chicago metropolitan area was about

6.6 million people.

The climate in the Argonne National Laboratory-East area is characterized as continental, with an average annual precipitation of 80 centimeters (31.5 inches). The area experiences about 40 thunderstorms annually, occasionally accompanied by hail, damaging winds, or tornadoes. The theoretical probability of a tornado strike at Argonne National Laboratory-East is about one every 1,200 years, although the site was struck by tornadoes in 1976 and 1978, with minor damage.

The Argonne National Laboratory-East site is located above about a 30-meter- (100-foot)-thick glacial till deposit on top of dolomite bedrock. The site is in Uniform Building Code Seismic Zone 1. Several areas of seismic activity are present at moderate distances from the site, but ground motions induced by these seismic sources are expected to be minimal at the site.

The Argonne National Laboratory-East site contains a number of small ponds and surface streams that enter the Des Plaines River about 2.0 kilometers (1.25 miles) southeast of the site center. Groundwater is extracted from two underlying aquifers. No aquifers in the region are considered sole-source aquifers by the U.S. Environmental Protection Agency.

4.7.2 Domestic Research and Test Reactors

Appendix E also identifies 55 non-DOE facilities representing domestic, licensed, small generators of SNF. They include training, research, and test reactors at universities, commercial establishments, and several Government installations. These facilities have been licensed by the U.S. Nuclear Regulatory Commission for reactor operation and the storage of the SNF they generate. Although they are not DOE facilities, past practices and long-term plans and agreements have always called for the SNF they generate to be transported to DOE facilities. In the past, this SNF was generally processed at the Savannah River Site, Hanford Site, or Idaho National Engineering Laboratory for recovery of the highly enriched uranium in their fuel. Under all but the No Action and Decentralization alternatives, these fuels would be transported to a DOE site for storage until ultimate disposition.

These 55 U.S. Nuclear Regulatory Commission licensed facilities, 40 of which are operated by universities, are located in 28 states. They are located in a wide variety of areas, ranging from rural locations to industrial research parks and urban university campuses, which does not permit a description of a typical affected environment for these facilities. Information on the environments of three of the larger of these U.S. Nuclear Regulatory Commission-licensed research reactors [the National Institute of Standards and Technology (former National Bureau of Standards), the Massachusetts Institute of Technology, and the University of Missouri reactors] is summarized in the following sections.

4.7.2.1 National Institute of Standards and Technology.

The National Institute of Standards and Technology reactor is located on the Institute's 233-hectare (576-acre) campus in the city of Gaithersburg, Maryland, about 20 miles northwest of downtown Washington, D.C. The 1990 population of Gaithersburg, a Washington suburban area, was about 39,500. The nearest site boundary is about 0.40 kilometer (0.25 mile) southwest of the reactor.

The climate of the area is moderate, with infrequent occurrences of severe weather. Although a number of winter storms and hurricanes have affected the general area, the site is not subject to flooding, and the recurrence interval for a tornado at the site is about one in 2,000 years. Air quality is primarily determined by the presence of 12-lane Interstate Highway 270, used by commuters to and from the downtown Washington, D.C., area and suburban residential areas.

There are no known major faults in the site vicinity, although the site region is moderately seismic (Seismic Zone l). The maximum ground acceleration for the site area was estimated to be 0.07g.

There are no discharges from the National Institute of Standards and Technology reactor to surface streams or groundwater; liquid wastes are processed before discharge to the local sanitary sewer system and have averaged 2.7 curies of tritium and 1.9 millicuries of other beta-gamma emitters per year from 1988 to 1992. Over the same period, the site released airborne emissions containing an average of 710 curies of argon-41 and 353 curies of tritium per year, well below the license limits for the site. However, individual or collective doses are not reported, and because site meteorological data are not monitored, doses cannot be reliably estimated.

4.7.2.2 Massachusetts Institute of Technology.

The Massachusetts Institute of Technology reactor, housed in a gas-tight building with 0.6-meter (2-feet) concrete shielding, is located on a 0.39-hectare (1-acre) site in a heavily industrialized section of Cambridge, Massachusetts, a few blocks from the main Massachusetts Institute of Technology campus and about 1.6 kilometer (1 mile) from Boston across the Charles River. The population of Cambridge was about 95,800 in 1990.

The meteorological conditions vary from highly stable with light winds to unstable atmospheric conditions with strong winds. Severe weather conditions are uncommon, and flooding of the area is not expected even under record rainfall conditions. Air quality is typical of an urban area.

The Cambridge area has been relatively free of earthquakes over the past 150 years, but it did experience an earthquake in 1755, which destroyed some buildings. The region is located in Seismic Zone 2, and the reactor is conservatively designed to withstand projected seismic activity.

There are no discharges from the Massachusetts Institute of Technology reactor to surface streams or groundwater; liquid wastes are processed before discharge to the local sanitary sewer system and have averaged 0.074 curies of tritium and 9.5 millicuries of other beta-gamma emitters per year from 1988 to 1992. Over the same period, the reactor released airborne effluents containing an annual average of 1,215 curies of argon-41, well below the license limits for the reactor. However, individual or collective doses are not reported, and because site meteorological data are not monitored, doses cannot be reliably estimated, particularly given the highly urbanized vicinity.

4.7.2.3 University of Missouri.

The Columbia Research Reactor is sited within a 34-hectare (85-acre) Research Park about 1.6 kilometers (1 mile) southwest of the main campus of the University of Missouri, located south of the main business district of Columbia, Missouri. The population of Columbia was about 69,000 in 1990. Agriculture is the predominant regional activity, although there are a number of small industrial activities in the area.

The climate of the region is continental, and high windspeeds are not uncommon; 150 kilometer per hour (94 mile per hour) winds have a recurrence interval of once in 100 years, but tornadoes are very uncommon. Air quality is representative of the nonurban midwest. Surface drainage from the site moves eventually to the Missouri River.

Columbia is located in the stable area of Missouri and, despite the proximity to the New Madrid area, the probability of seismic damage in the area is low as reflected by its location in Seismic Zone 1.

There are no discharges from the University of Missouri/Columbia Research Reactor to surface streams or groundwater; liquid waste is processed before discharge to the local sanitary sewer system and has averaged 0.21 curie of tritium and 25.6 millicuries of other beta-gamma emitters per year from 1988 to 1992. Over the same period, the reactor released airborne effluents containing an annual average of about 660 curies of argon-41 and about 7 curies of tritium, well below the license limits for the reactor. However, individual or collective doses are not reported, and because site meteorological data are not monitored, doses cannot be reliably estimated.

4.7.3 Spent Nuclear Fuel from Special Nuclear Power Plants

Three facilities house SNF from power reactors for which DOE has assumed responsibility. Unlike the facilities discussed previously, no additional SNF is either being generated at or being transported to these storage facilities. These facilities include the West Valley Demonstration Project, in West Valley, New York; the former Fort St. Vrain Nuclear Power Plant in Colorado; and the Babcock & Wilcox Research Center, Lynchburg, Virginia. Their environmental characterizations are summarized in the following sections and presented in more detail in Appendix E.

4.7.3.1 West Valley Demonstration Project.

The West Valley Demonstration Project occupies an 88-hectare (220-acre) site formerly housing the first United States commercial nuclear fuel processing plant, within a larger 1,341-hectare (3,345-acre) site known as the Western New York Nuclear Service Center. The Center is located in Cattaraugus County, a rural area of western New York State, about 50 kilometers (31 miles) south of Buffalo, New York, and 40 kilometers (25 miles) east of Lake Erie.

A 60-meter (200-foot) onsite meteorological tower is operated by DOE at the West Valley Demonstration Project. A review of the West Valley Demonstration Project tower's 1992 data indicates that the prevailing wind was from the south-southeast with a mean wind speed of 2.4 meters per second (5.4 miles per hour). The precipitation for 1992 was 18 centimeters (7.1 inches) above the annual average of 104 centimeters (40.9 inches). The onsite 1992 wind data and National Weather Service wind data collected at the Buffalo airport did not compare well, thereby indicating that the Buffalo airport is not representative for predicting conditions at the West Valley Demonstration Project.

The West Valley Demonstration Project is located within the Cattaraugus Highlands, which is a transitional zone between the Appalachian Plateau Province and the Great Lakes Plain. No fold or fault of any consequence is recognized within the site. The Clarendon-Linden structure is the closest active "capable" earthquake- (fault-) producing feature known to exist in the region. It is approximately 37 kilometers (23 miles) from the site. The site has experienced a moderate amount of relatively minor seismic activity. During historical times, ground motion at the site probably has not exceeded a Modified Mercalli Intensity of IV or a horizontal acceleration of 0.05g. It is estimated that the maximum earthquake on the Clarendon-Linden structure would produce an earthquake of Modified Mercalli Intensity of VI or VII and a maximum horizontal acceleration of approximately 0.12g at the site.

The West Valley Demonstration Project is located in the Cattaraugus Creek drainage basin, which is part of the Great Lakes - St. Lawrence watershed. All surface drainage from the West Valley Demonstration Project is to Buttermilk Creek, which flows into Cattaraugus Creek and ultimately into Lake Erie. The uppermost water-bearing unit underlying the West Valley Demonstration Project is a hydrologically isolated part of the Cattaraugus Creek Aquifer System, which has been designated a sole source aquifer by the U.S. Environmental Protection Agency. This unit is included in the sole source designation due to its hydrologic similarity and proximity to the producing Cattaraugus Creek Aquifer.

4.7.3.2 Fort St.

Vrain. The Fort St. Vrain site is located in Weld County in northeastern Colorado, approximately 5.6 kilometers (3.5 miles) northwest of the town of Platteville, 0.8 kilometer (0.5 mile) west of the South Platte River, and 56 kilometers (35 miles) north of Denver. The Fort St. Vrain site consists of 1,132 hectares (2,798 acres). Based on the 1980 census, the population within an 8-kilometer (5-mile) radius of the site was estimated to be 3,148, with 1,662 residing in the town of Platteville (USBC 1982). Most of the land in the immediate area of the site is disturbed, agricultural land.

The general climate around the Fort St. Vrain site is generally mild. In this semi-arid region, the precipitation averages 25 to 38 centimeters (10 to 15 inches) a year, mostly from thunderstorms in late spring and summer. Northeastern Colorado has moderate thunderstorm activity. The region typically experiences 5 tornadoes per year per 25,900 square kilometers (10,000 square miles), with peak tornado activity occurring during the month of June. A study of tornadoes in the area concluded that 161-kilometer-per hour- (100-mile-per-hour) winds should constitute maximum wind forces to be expected at Fort St. Vrain.

The Fort St. Vrain site is located on the east flank of the Colorado Front Range, a complexly faulted anticlinal arch. Numerous faults and smaller folds are superimposed on the arch and are related to the uplift of the Front Range. The Fort St. Vrain site has not experienced any observed earthquake activity. A field examination of the area produced no evidence of recent movement along any of the known faults. The closest area of recent activity is about 40 kilometers (25 miles) south of the site. The site is located in Seismic Zone 1.

The nearest major surface water features to the Fort St. Vrain site are the South Platte River, about 0.8 kilometer (0.5 mile) east of the site, and the St. Vrain Creek, about 1.2 kilometer (0.75 mile) west of the site. Local surface water diversions from these rivers, which feed irrigation ditches to support agriculture, are somewhat closer, about 0.5 kilometer (0.33 mile) east and west of the site and about 0.64 kilometer (0.4 mile) to the north of the site, and an irrigation ditch is located 0.16 kilometer (0.1 mile) to the south of the site.

4.7.3.3 Babcock & Wilcox Research Center, Lynchburg.

The Babcock & Wilcox Research Center occupies a 1.6-hectare (4-acre) fenced area within Babcock & Wilcox's 374-hectare (925-acre) Mount Athos site. The research center is in Campbell County, Virginia, near the James River, approximately 6.5 kilometers (4 miles) east of the city of Lynchburg. The research facility and the nearby city of Lynchburg are centrally located within the area of Amherst, Appomattox, Bedford, and Campbell Counties. The combined population of these counties is about 180,000.

The climate of the Lynchburg area is influenced by cold and dry polar continental air masses in the winter and warm and humid gulf maritime air masses in the summer. Rainfall amounts can be expected to reach 102.4 centimeters (40.3 inches) in any given year. Severe weather is limited to thunderstorms with a low probability of tornadoes. The mean number of thunderstorms occurring at Lynchburg is approximately 22 per year. The probability of a tornado actually striking the site is 3.0 10-4 per year, with a recurrence interval of 3,333 years.

The land at the Babcock & Wilcox Research Center is characterized by scattered hills of various dimensions lying eastward from the main chain of the Blue Ridge Mountains. The site is located in a western part of the central Virginia cluster region, which is classified as Seismic Zone 2. Approximately 121 earthquakes with epicenters in Virginia have occurred during the last 236 years. Two earthquakes have been recorded with intensities sufficient to cause some damage, but these were not in the area of the Center. Earthquakes are not expected to cause serious damage to the Lynchburg facilities nor result in release of hazardous materials.

The James River is formed about 154 kilometers (96 miles) upstream of the site by the confluence of the Jackson and Cowpasture Rivers. The James River flows generally south-southeast from the Valley and Ridge Province to the Atlantic Ocean through the Hampton Roads and Chesapeake Bay. The annual average flow rate of the James River at the plant is estimated to be about 110 cubic meters per second (3,900 cubic feet per second). The largest recent flood occurred in November 1985 and had a flood stage of 163 meters (534 feet) above mean sea level at Lynchburg. The groundwater elevation is between 134 and 140 meters (440 and 460 feet) above mean sea level, which is 3 meters (10 feet) below surface elevation at the annual average flow rate. Because of the relative impermeability of the silt and clay topsoils, neither the water in surface soils nor river flood water has a major effect on the groundwater supply or quality.

References Chapter 4

NNPP (Naval Nuclear Propulsion Program), 1993, Environmental Monitoring and Disposal of Radioactive Wastes from U.S. Naval Nuclear Powered Ships and Their Support Facilities, Report NT-93-1, Washington, D.C., February.

USBC (U.S. Bureau of the Census), 1982, 1980 Census of Population and Housing, Washington, D.C.

USBC (U.S. Bureau of the Census), 1992, 1990 Census of Population and Housing, Washington, D.C.

5. ENVIRONMENTAL CONSEQUENCES

This chapter presents the potential environmental consequences of implementing each of the alternatives described in Chapter 3. To focus on the most significant issues in the design of the SNF Program, this chapter summarizes and simplifies the more detailed site-specific analyses of environmental consequences presented under separate cover as self-contained appendices to Volume 1. The intent is to provide a collection of summary information across DOE sites, SNF interim storage alternatives, and issue areas without recounting the detail of the separate appendices.

The Centralization alternative generally produces the greatest impacts, with somewhat smaller impacts associated with the 1992/1993 Planning Basis and Regionalization alternatives. The No Action alternative may appear to have the least impact in some of the categories analyzed, such as transportation, but it also produces larger impacts in others, such as estimated radiation doses as the result of accidents. In addition, the increased exposure of workers to radiation and the increased risks of release of radioactive material to the environment with the continuing degradation of certain types of DOE SNF are potential impacts that cannot be completely analyzed.

This chapter is organized into eight sections. The disciplines (topical areas) studied that result in potential impacts, are of general public interest, or may help to discriminate among sites for alternatives are discussed in Section 5.1. In general, the consequences presented in Section 5.1 relate to socioeconomic impacts, electricity use, waste generation, and radiological and transportation impacts. The disciplines that were studied that showed small impacts or clearly did not discriminate among sites or alternatives are discussed in Section 5.2. Sections 5.3 through 5.8 address cumulative impacts, unavoidable adverse environmental effects, the relationship between short-term use and long-term productivity, irreversible and irretrievable commitments of resources, potential mitigation measures, and environmental justice, respectively.

The period covered in this EIS is the 40 years from 1995 to 2035. Detailed impact analyses are performed for the time period from 1995 to 2005. Normal operation impacts at the Idaho National Engineering Laboratory are then projected for the remaining 30 years covered by this EIS. The level of site-specific detail presented in Sections 5.1 and 5.2 is commensurate with the size of the SNF inventory and the number and types of sites where SNF would be stored. Therefore, the analyses of the major DOE and naval sites are more detailed than the analyses for the other generator/storage locations that would have limited inventories under the No Action and Decentralization alternatives. There are five major DOE sites that are or may be responsible for managing the great majority of SNF: Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, Oak Ridge Reservation, and Nevada Test Site. The DOE did not consider the Nevada Test Site to be a preferred site for the management of SNF because of the State of Nevada's current role as the host site for the Yucca Mountain Site Characterization Project and the Nevada Test Site's lack of SNF management facilities and high-level waste infrastructure. Minor sites are the university and government reactor sites and the three facilities that store small quantities of SNF for which DOE has responsibility: West Valley Demonstration Project, Babcock & Wilcox Research Center, Lynchburg, and Fort St. Vrain.

For more detailed information on analyses of environmental impacts, and for a discussion of the analyses supporting the consequences reported here, refer to the appropriate site-specific appendix. These site-specific appendices, under separate cover, are organized as follows:

Appendix	Focus of Appendix
A	Hanford Site
B	Idaho National Engineering Laboratory
C	Savannah River Site
D	Naval Nuclear Propulsion Program
E	Other Generator/Storage Locations
F	Nevada Test Site and Oak Ridge Reservation

Appendix K presents site-specific data compiled from Appendices A through F that were used in developing the discussion of environmental consequences. The summary tables in Appendix K allow comparison of quantitative impacts (for example, increases or decreases in direct employment resulting from implementation of an alternative) among sites.

Appendix L presents an evaluation of environmental justice considerations at each of the alternative sites considered in this EIS. Environmental consideration and exposure pathways were evaluated within a 80-kilometer (50-mile) radius surrounding each of 10 potential sites of proposed activities. This 80-kilometer (50-mile) radius is in keeping with analysis conducted under the National Environmental Policy Act regarding proposed DOE activities to identify environmental impacts from proposed activities. This 80-kilometer (50-mile) radius represents the limit in which any impacts are considered to be of any potential significance. Minority and low-income communities surrounding each alternative site were identified through the use of a Geographical Information System, based on 1990 U.S. Census data. Demographic maps are provided for each site under consideration in Appendix L.

5.1 Environmental Consequences of Key Discriminator Disciplines

This section presents the environmental consequences of the alternatives, focusing on the key discriminator disciplines-those that may differentiate among sites, have the potential for a more significant impact, or are of general public interest. This section is organized in two parts: a background discussion providing perspective for each discipline and a presentation of consequences by alternative, discipline, and site.

5.1.1 Background

The following discussion provides background and perspective for the environmental consequences presented in Section 5.1.

5.1.1.1 Socioeconomics.

Socioeconomic impacts are defined in terms of direct and secondary effects. Direct effects include changes in site employment and expenditures resulting from SNF-related construction and operation. Secondary effects include changes that result from regional purchases, nonpayroll expenditures, and payroll spending by site employees. For the major DOE sites, existing projections (regardless of SNF management decisions) indicate that jobs will be lost during the next few years for all sites. Potential SNF management impacts onsite and regional employment were considered in light of this trend.

For the sites considered, only minor increases in site employment over the declining job baseline would result from SNF management; therefore, secondary effects were considered as a lessening of the rate of job loss, without substantial impacts on associated regions. At the Idaho National Engineering Laboratory, the potential for appreciable job losses exists under certain alternatives. These reductions would contribute to an overall regional decline. The reductions are not anticipated to be significant, however, because they would occur over several years. For the naval sites, the number of staff required to manage SNF management facilities would be approximately less than 1 percent of site employment and less than 1/25 of 1 percent of regional employment, so secondary impacts were also considered small in this analysis. For other generator/storage locations, job creation was expected to be minimal even under the No Action alternative where long-term management of SNF would be required should operating reactors be required to shut down. The number of staff involved for long-term SNF management would be small in relation to existing staffing levels at these reactors.

With employment as an indicator, small changes in population are anticipated, creating minimal changes in demand on regional supporting infrastructures. The number of direct jobs that would be created under each alternative as a result of SNF management activities was estimated for each site. The employment graphs shown on Figures 5-1 through 5-9 (presented and discussed fully with the alternatives) represent the 10-year average of the incremental change in direct employment resulting from SNF management. Secondary effects, such as the need for additional housing and improved community services are discussed if an impact is indicated. Details on the socioeconomic impact analysis, as well as the baseline projections from which comparisons were made, are provided in Appendices A through F. Employment increases and decreases that are presented in the text are 10-year averages rather than the actual maximum increase or decrease in any single year as presented in Appendix A through F. Please see the specific site appendix for actual annual employment values.

5.1.1.2 Utilities (Electricity).

New facilities (or the restarting of idle facilities) would result in increased demands on water, power, and sewage. Water and sewage requirements are considered minimal and are discussed in Section 5.2.9. However, power consumption under some of the alternatives would exceed existing capacity at certain sites and this is discussed in more detail in this section. Electricity requirements by site and by alternative vary significantly depending on whether a site is processing or storing SNF. For example, at the Hanford Site, the annual increase in power use from SNF management activities could vary from 0 megawatt-hours per year under the No Action alternative when storing only, to a maximum of about 130,000 megawatt-hours per year under the Centralization alternative when processing (Appendix K, Volume 1). In addition, the operation of an expended core facility consumes approximately 10,000 megawatt-hours per year of electricity. Therefore, the power requirements would be highest under alternatives where both processing and operating an expended core facility occur simultaneously. The graphs of electricity use in Figures 5-1 through 5-9 show the maximum and minimum incremental change in power consumption that would result from implementing the alternative. Current capacities and baseline usage of utilities and energy from which comparisons are made are discussed in Appendices A through F of Volume 1.

5.1.1.3 Materials and Waste Management.

There are few impacts on materials and waste management activities except when SNF is processed. Stabilization of SNF, depending on the technology, may yield high-level, transuranic, low-level, mixed, and hazardous wastes. The wastes must usually be further treated to make them safe for transport, storage, or disposal. The capacity of sites for additional storing of high-level and transuranic wastes is generally limited. Low-level wastes are normally disposed of onsite at the major DOE facilities. Hazardous wastes are normally treated in some way and then disposed of in approved disposal facilities onsite or offsite. A few categories of mixed waste are being treated, but most are in storage awaiting development of treatment capabilities. The graphs of waste generation in Figures 5-1 through 5-9 illustrate the estimated annual average of low-level waste and high-level, transuranic, and mixed waste that each alternative would generate between 1995 and 2005. Site-specific details on materials and waste management and the current status of waste management activities at the sites are discussed in Appendices A through F.

5.1.1.4 Occupational and Public Health and Safety.

Radiation Effects-Radiation exposure and its consequences are topics of interest to the general public near nuclear facilities. Therefore, this EIS places more emphasis on the consequences of exposure to radiation than on other topics, even though the effects of radiation exposure under most of the circumstances evaluated in this EIS are small. This subsection explains basic concepts used in the evaluation of radiation effects to provide the background for later discussions of impacts.

The effects on people of radiation that is emitted during disintegration (decay) of a radioactive substance depends on the kind of radiation (alpha and beta particles, and gamma and x-rays) and the total amount of radiation energy absorbed by the body. The total energy absorbed per unit quantity of tissue is referred to as absorbed dose. The absorbed dose, when multiplied by certain quality factors and factors that take into account different sensitivities of various tissues, is referred to as effective dose equivalent, or where the context is clear, simply dose. The common unit of effective dose equivalent is the rem (1 rem equals l,000 millirem).

An individual may be exposed to ionizing radiation externally, from a radioactive source outside the body, and/or internally, from ingesting or inhaling radioactive material. The external dose is different from the internal dose. An external dose is delivered only during the actual time of exposure to the external radiation source. An internal dose, however, continues to be delivered as long as the radioactive material remains in the body, although both radioactive decay and elimination of the radionuclide by ordinary metabolic processes decrease the dose rate with the passage of time. The dose from internal exposure is calculated over 50 years following the initial exposure.

The maximum annual allowable radiation dose to an individual of the public from DOE-operated nuclear facilities is 0.1 rem (100 millirem) per year (DOE Order 5400.5) (DOE 1993b). All DOE and naval facilities covered by this EIS operate well below this limit (see Chapter 4). It is estimated that the average individual in the United States receives a dose of about 0.3 rem (300 millirem) per year from natural sources of radiation. For perspective, a modern chest x-ray results in an approximate dose of 0.008 rem (8 millirem), while a diagnostic hip x-ray results in an approximate dose of 0.083 rem (83 millirem). A person must receive an acute (short-term) dose of approximately 600 rem (600,000 millirem) before there is a high probability of near-term death (NAS/NRC 1990).

Radiation can also cause a variety of ill-health effects in people. The most significant ill-health effect to depict the consequences of environmental and occupational radiation exposures is the induction of latent cancer fatalities. This effect is referred to as latent cancer fatalities because the cancer may take many years to develop and for death to occur.

The collective (or population) dose to an exposed population is calculated by summing the estimated doses received by each member of the exposed population. This total dose received by the exposed population is measured in person-rem. For example, if 1,000 people each received a dose of 0.001 rem (1 millirem), the collective dose is 1,000 persons 0.001 rem (1 millirem) = 1 person-rem. Alternatively, the same collective dose (1 person-rem) results from 500 people each of whom received a dose of 0.002 rem (2 millirem) (500 persons 0.002 rem = 1 person-rem).

The factor that this EIS uses to relate a dose to its effect is 0.0004 latent cancer fatalities per person-rem for workers and 0.0005 latent cancer fatalities per person-rem for individuals among the general population. The latter factor is slightly higher because of the presence of individuals in the general public that may be more sensitive to radiation than workers (for example, infants).

These concepts may be applied to estimate the effects of exposing a population to radiation. For example, in a population of 100,000 people exposed only to background radiation [0.3 rem (300 millirem) per year], 15 latent cancer fatalities per year would be inferred to be caused by the radiation [100,000 persons 0.3 rem (300 millirem) per year 0.0005 latent cancer fatalities per person-rem = 15 latent cancer fatalities per year].

Sometimes, calculations of the number of latent cancer fatalities associated with radiation exposure do not yield whole numbers, and, especially in environmental applications, may yield numbers less than 1.0. For example, if a population of 100,000 were exposed as above, but to a total dose per individual of only 0.001 rem (1 millirem), the collective dose would be 100 person-rem, and the corresponding estimated number of latent cancer fatalities would be 0.05 [100,000 persons 0.001 rem (1 millirem) 0.0005 latent cancer fatalities/person-rem = 0.05 latent fatal cancers].

How should one interpret a noninteger number of latent cancer fatalities, such as 0.05? The answer is to interpret the result as a statistical estimate. That is, 0.05 is the average number of deaths that would be expected if the same exposure situation were applied to many different groups of 100,000 people. In most groups, nobody (0 people) would incur a latent cancer fatality from the 0.001 rem (1 millirem) dose each member would have received. In a small fraction of the groups, 1 latent fatal cancer would result; in exceptionally few groups, 2 or more latent fatal cancers would occur. The average number of deaths over all the groups would be 0.05 latent fatal cancers (just as the average of 0, 0, 0, and 1 is -, or 0.25). The most likely outcome is 0 latent cancer fatalities.

These same concepts apply to estimating the effects of radiation exposure on a single individual. Consider the effects, for example, of exposure to background radiation over a lifetime. The "number of latent cancer fatalities" corresponding to a single individual's exposure over a (presumed) 72-year lifetime to 0.3 rem (300 millirem) per year is the following:

1 person 0.3 rem (300 millirem)/year 72 years 0.0005 latent cancer fatalities/person-rem = 0.011 latent cancer fatalities.

Again, this should be interpreted in a statistical sense; that is, the estimated effect of background radiation exposure on the exposed individual would produce a 1.1-percent chance that the individual might incur a latent fatal cancer caused by the exposure. Said another way, about 1.1 percent of the population is estimated to die of cancers induced by the radiation background.

The dose-to-risk conversion factors presented above and used in this EIS to relate radiation exposures to latent cancer fatalities are based on the "1990 Recommendations of the International Commission on Radiation Protection" (ICRP 1991). These conversion factors are consistent with those used by the U.S. Nuclear Regulatory Commission in its rulemaking "Standards for Protection Against Radiation" (FR 1991). In developing these conversion factors, the International Commission on Radiological Protection reviewed many studies, including Health Effects of Exposure to Low Levels of Ionizing Radiation (BEIR V) and Sources, Effects and Risks of Ionizing Radiation. These conversion factors represent the best-available estimates for relating a dose to its effect; most other conversion factors fall within the range of uncertainty associated with the conversion factors that are discussed in NAS/NRC (1990). The conversion factors apply where the dose to an individual is less than 20 rem (20,000 millirem) and the dose rate is less than 10 rem (10,000 millirem) per hour. At doses greater than 20 rem (20,000 millirem), the conversion factors used to relate radiation doses to latent cancer fatalities are doubled. At much higher doses, prompt effects, rather than latent cancer fatalities, may be the primary concern. Unusual accident situations that may result in high radiation doses to individuals are considered special cases.

In addition to latent cancer fatalities, other health effects could result from environmental and occupational exposures to radiation. These effects include nonfatal cancers among the exposed population and genetic effects in subsequent generations. Table 5-1 shows the dose-to-effect factors for these potential effects, as well as for latent cancer fatalities. For clarity and to allow ready comparison with health impacts from other sources, such as those from chemical carcinogens, this EIS presents estimated effects of radiation only in terms of latent cancer fatalities. The nonfatal cancers and genetic effects are less probable consequences of radiation exposure. Estimates of the total detriment (fatal cancers, nonfatal cancers, and genetic effects) due to radiation exposure may be obtained from the estimates of latent cancer fatalities presented in this EIS by multiplying by 1.4 for workers and by 1.46 for the general public.

Table 5-1. Risk of latent cancer fatalities and other health effects from exposure to radiation. ,b

Population(c)	Latent cancer fatality	Nonfatal cancer	Genetic effects	Total detriment
Workers	0.0004	0.00008	0.00008	0.00056
General public	0.0005	0.0001	0.00013	0.00073

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a. When applied to an individual, units are lifetime probability of latent cancer fatalities per rem (or 1,000 millirem) of radiation dose. When applied to a population of individuals, units are excess number of cancers per person-rem of radiation dose. Genetic effects as used here apply to populations, not individuals.

b. Source: ICRP (1991).

c. The difference between the worker risk and the general public risk is attributable to the fact that the general population includes more individuals in sensitive age groups (that is, less than 18 years of age and over 65 years of age).

During SNF handling and transportation, the principal radiation hazard is the direct radiation emitting from the SNF. In comparison, the hazard from release of radioactive fission products (gases and particulates) from within the solid SNF is small. Without adequate shielding, the radiation levels at the surface of the SNF are often high enough to induce a prompt fatality. Fortunately, this radiation is easily attenuated or stopped with the insertion of shielding materials such as lead, steel, or water between the SNF and the worker. Because radiation intensity decreases with distance, maintaining a distance of a few hundred meters also offers adequate protection from the radiation from unshielded SNF. For example, 10 CFR 71 requires sufficient shielding on shipping casks to reduce radiation levels at 2 meters (7 feet) from the cask to 0.01 rem (10 millirem) per hour or less. At 100 meters (328 feet), the distance effect would reduce this 0.01 rem (10 millirem) per hour by a factor of about 2,500, which would not be detectable.

During SNF interim storage, trace quantities of radioactive isotopes (principally gases and particulate fission products) may also be released to the environment from severely corroded SNF. These releases would result in small doses to the workers in the immediate vicinity of the SNF and, through atmospheric dispersion and groundwater pathways, would ultimately result in very small doses to members of the nearby general population.

Accidents involving SNF can also result in radiation releases and exposures. For most accidents, a very small fraction of the radioactive material within the SNF is released. This is because the SNF is in a solid form and the radioactive elements are intermingled within the solid SNF. Significant quantities of these radioactive elements can be released only when the accident generates enough energy to break up or cause particles of SNF to be released to the atmosphere. For most accidents, the energy is not high enough to cause much damage to the SNF and a small fraction of the radioactive material is released.

One type of accident, an accidental nuclear criticality (uncontrolled chain reaction), can release large quantities of direct radiation, as well as fission products and heat. Within a few tens of meters of the incidents, doses from direct radiation can be fatal. Further away, doses are principally from the released fission product gases and particulates. This type of accident is well understood and is easily prevented when handling solid materials such as SNF.

Risk-Another concept important to the presentation of results in this EIS is the concept of risk. Risk is most important when presenting accident analysis results. The chance that an accident might occur during the conduct of an operation is called the probability of occurrence. An event that is certain to occur has a probability of 1 (as in 100 percent certainty). The probability of occurrence of an accident is less than one because accidents, by definition, are not certain to occur. If an accident is expected to happen once every 5 years, the frequency (and probability) of occurrence is 0.2 per year (1 occurrence 5 years = 0.2 occurrences per year).

Once the frequency (occurrences per year) and the consequences (for radiation effects, measured in terms of the number of latent cancer fatalities caused by the radiation exposure) of an accident are known, the risk can be determined. The risk per year is the product of the annual frequency of occurrence times the number of latent cancer fatalities. This annual risk expresses the expected number of latent cancer fatalities per year, taking account of both the annual chance that an accident might occur and the estimated consequences if it does occur.

For example, if the frequency of an accident were 0.2 occurrences per year and the number of latent cancer fatalities resulting from the accident were 0.05, the risk would be 0.01 latent cancer fatalities per year (0.2 occurrences per year 0.05 latent cancer fatalities per occurrence = 0.01 latent cancer fatalities per year). Another way to express this risk (0.01 latent cancer fatalities per year) is to note that if the operation subject to the accident continued for 100 years, one latent cancer fatality would be likely to occur because of accidents during that period. This is equivalent to 1 chance in 100 that a single latent cancer fatality would be caused by the accident source for each year of operation.

A frame of reference for the risks from accidents associated with SNF management alternatives can be developed in the same way. For an average resident in the vicinity of the Idaho National Engineering Laboratory, the risk of a latent cancer fatality caused by the water draining from the Expended Core Facility after a large earthquake would be approximately 1.7 10-7 per year (see Chapter 5 of Appendix D). This risk can be compared with the lifetime risks of death from other accidental causes to gain a perspective. For example, the risk of dying from a motor vehicle accident is about 1 in 80. Similarly, the risk of death for the average American from fires is approximately 1 in 500, and for death from accidental poisoning, the risk is about 1 in 1,000 (NNPP 1993). These comparisons are not meant to imply that risks of a latent cancer fatality caused by DOE operations are trivial, only to show how they compare with other, more common risks. Radiological risks to the general public from DOE operations are considered to be involuntary risks, as opposed to voluntary risks such as operating a motor vehicle.

Radiological Accidents-Activities associated with transporting, receiving, handling, processing, and storing SNF involve substantial quantities of radioactive materials and limited quantities of toxic chemicals. Either routine SNF operations or accidents involving either radioactive materials or toxic chemicals can result in exposure to workers or members of the public, or contamination of the surrounding environment.

A number of existing accident analyses were evaluated to find a small group with relatively severe consequences or risks. These accidents included events such as small fires; severe accidents that a facility is designed to withstand; and beyond-design-basis events, which a facility is not designed to withstand. These accidents included those initiated by internal events, such as operational errors; those initiated by natural external phenomena, such as floods, tornados, and earthquakes; and those initiated by human-influenced external events, such as aircraft crashes and nearby explosions or toxic material releases. The accidents evaluated included those with an estimated probability ranging from 1 chance in 1,000,000 to 1 chance in 10,000,000 per year.

Appendices A through F summarize the possible accidents involving SNF operations at each of the sites and evaluate the potential consequences of the accidents that present the highest risk, in terms of estimated frequency of occurrence multiplied by consequences, to the workers and the general public. As might be expected, the highest consequences, though frequently not the highest risk, were often found to be associated with the accidents with the lowest probabilities.

The accidents selected, the amount of radioactive and toxic materials released under the accident conditions, and the estimated probabilities were based on existing safety analyses for the SNF-related operations at each site, or for comparable operations at other sites. The accident evaluations also considered the 40 to 50 years of operational experience with SNF at the sites.

Accident consequences were analyzed utilizing radioactive and toxic material release estimates for each accident. The downwind concentrations of materials released in accidents were then calculated for a range of potential receptor locations and potential doses to individuals or people at those locations evaluated. Doses were evaluated for (a) an individual 100 meters (328 feet) downwind of the facility location where the release occurs, (b) a hypothetical resident at the site boundary nearest to the facility where the release occurs (called the maximally exposed offsite individual), and (c) the general population within 80 kilometers (50 miles) of the release location. The potential impacts to workers in the immediate vicinity of the accident were analyzed qualitatively.

Dispersion in air from the release site was estimated with both typical (50th percentile) and unlikely (95th percentile) meteorological conditions. The unlikely weather conditions represent those that would result in high air concentrations of the material released, elevating the exposure of affected individuals. Concentrations and human exposures are lower than these values 95 percent of the time. Dispersion was calculated using the GENII computer code (Napier et al. 1988) for all sites except Savannah River Site, for which the site-specific AXAIR89Q code was used (including 95 percent meteorologic conditions). Although the modeling for the Savannah River Site was performed using a different code, that code has been validated and shown to be consistent with the GENII code and conservative in its model results. The dispersion of nonradioactive materials was modeled using EPIcode (Homann 1988).

Nonradiological Accidents-Accidents with nonradiological effects include industrial hazards from construction and normal operation. Accidents that may affect occupational or public health were evaluated for each of the alternatives at each of the potentially affected sites and facility locations. The maximum reasonably foreseeable accidents include chemical spills, fires, and worker accidents. The accidents estimated to exceed the most widely accepted accident exposure (toxicological) guidelines, such as the Emergency Response Planning Guideline-3 and the Threshold Limit Value of the American Conference of Governmental Industrial Hygienists, are summarized in Section 5.1, Volume 1. Exceeding these concentrations would result in an unacceptable likelihood that the worker or public would experience or develop life-threatening or very serious toxicological effects. The analysis methodologies and the accident descriptions are discussed in Appendices A through F.

Industrial accidents that do not involve the release of chemicals could occur at each of the existing or proposed storage and generation locations during the transition/construction phase at approximately current rates. Construction accidents would primarily occur during the construction period (estimated to be approximately 8 years under the Centralization alternative). Construction fatalities are estimated to be approximately one per year at the centralized site for the Centralization alternative only. After the SNF is transported to the centralized facility, normal operations would not be expected to be fatal accident-free, but fatal accident frequency is estimated to be less than one accident per year. The sites that are not selected for the centralized facilities would be expected to have less than one fatal accident per year throughout the SNF interim management period.

5.1.1.5 Transportation.

In this EIS, one of the ways that may be used to discriminate between alternatives is through the transportation impacts associated with each alternative. Some alternatives, such as the No Action alternative, would involve limited transportation of SNF and have few transportation impacts; while other alternatives, such as the Centralization options, would involve extensive transportation of SNF and have greater transportation impacts.

SNF is transported in large, heavy containers called shipping casks. Shipping casks must meet stringent Federal standards and are designed and constructed to contain the radioactivity in SNF during severe transportation accidents. There are also standards that describe the routing requirements for SNF shipments. Because of the stringent standards for SNF shipping casks, the U.S. Nuclear Regulatory Commission has estimated that shipping casks will withstand 99.4 percent of truck and rail accidents without sustaining damage sufficient to breach the shipping cask. Only in the worst physically conceivable conditions, which are clearly of low probability, can the shipping cask be so damaged that there is a significant release of radioactivity to the environment.

Transportation impacts may be divided into two parts: (1) the impacts due to incident-free transportation and (2) the impacts due to transportation accidents. For incident-free transportation and transportation accidents, impacts may be further divided into two parts: (1) nonradiological impacts and (2) radiological impacts. The nonradiological impacts are composed of the vehicular impacts of transportation, such as vehicular emissions and traffic accidents, and are not related to the radioactivity present in the shipments.

In contrast to the nonradiological impacts, the radiological impacts are due to the radioactivity present in SNF shipments. In the case of incident-free transportation, the radiological impacts result from the radiation field that surrounds the SNF shipping cask. These impacts are estimated for workers and the general population along the transportation route. In the case of transportation accidents, the radiological impacts would result from the radioactivity released from the SNF shipping cask during an accident. These impacts are also estimated for the general population along the transportation route.

This EIS evaluated a full range of transportation accidents, up to and including accidents with very low probability, estimated to be on the order of one in 1 million years. In addition, the consequences of severe transportation accidents were evaluated. The probability of these severe accidents was estimated to be on the order of one in 10 million years.

For both incident-free transportation and transportation accidents, methodology developed by the

U.S. Nuclear Regulatory Commission was used to estimate impacts. These impacts were quantified in terms of the estimated number of radiation-related cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions and traffic accidents associated with each alternative. Appendices A, B, C, D, F, and I contain more details on the methodology, data, and assumptions used to develop these estimates.

5.1.1.6 Uncertainties and Conservatism.

The calculations in this EIS have generally been performed in such a way that the estimates of risk provided are unlikely to be exceeded during either normal operations or in the event of an accident. For routine operations, the results of monitoring actual operations provide realistic estimates of source terms, which when combined with conservative estimates of the effects of radiation, produce estimates of risk that are very unlikely to be exceeded. The effects for all alternatives have been calculated using the same source terms and other factors, so this EIS provides an appropriate means of comparing potential impacts on human health and the environment.

The analyses of hypothetical accidents are based on the calculations that in turn must be based on sequences of events and models of effects that have not occurred. The models have attempted to provide estimates of the probabilities, source terms, pathways for dispersion and exposure, and the effects on human health and the environment that are as realistic as possible. In many cases, the probability of the accidents postulated is very low and little experience is available; thus, the consequences are uncertain. This has required the use of models or values for input that produce estimates of consequences and risks that are higher than would actually occur because of the desire to provide results that will not be exceeded.

All the alternatives have been evaluated using the same methods and data, allowing a fair comparison of all the alternatives on the same basis. It should be observed that, even using these conservative analytical methods, the risks associated with implementing any of the alternatives are small.

5.1.2 No Action Alternative

Under the No Action alternative, minimal actions would be taken for safe and secure management of SNF. SNF would not be transported to or from DOE facilities after a transition period, and facility upgrades or replacements and onsite fuel movements at DOE sites would be limited. Existing research and development activities at DOE sites would continue, but no new projects would be initiated. Naval SNF would be stored at naval sites at or near the point of refueling or defueling without examination at the Idaho National Engineering Laboratory. SNF from smaller DOE sites and university and other Government reactors would be stored at those reactors, and the special-case commercial fuels would remain at their current location. No foreign research reactor fuels would be accepted.

If this alternative were implemented, the Expended Core Facility at the Idaho National Engineering Laboratory would be shut down, the naval sites would store SNF in transport casks at naval sites, and the smaller DOE and university and other Government reactor sites would store the SNF they generate onsite. After a period of time, some smaller reactors would shut down to avoid the expense of building storage facilities, and the spent fuel would be stored in the reactor vessel.

In reviewing the impacts of the No Action alternative, it should be recognized that the consequences summarized in Figure 5-1 only approximately represent the consequences of this alternative. These consequences fall within four categories that may apply to one or more sites: increasing the potential for higher radiation exposures because of degrading fuels, increasing the potential for higher radiation exposures because of the location of SNF in or near major population centers, causing a potential loss of employment because research reactors would be shut down, and postponing the generation of wastes associated with research and converting SNF to a form acceptable for disposition. These issues are discussed in the following paragraphs.

Because there would be minimal actions taken to stabilize fuel under the No Action alternative, the frequency of an SNF-related radiation accident could increase as the stored fuels deteriorate with time. The lack of structural integrity of the fuel in some instances could result in an increase in handling-related accidents. In addition, releases from stored fuels could increase, increasing population doses, as the number of cladding failures increase. While the DOE is committed under the No Action alternative to ensure safe and secure management of SNF, future deterioration of fuels and facilities may increase accident risks over current risk estimates.

Under this alternative, DOE-managed SNF would be stored in over 50 locations around the country, many of which are in areas of relatively high population density. While the risk of exposure would be small for this alternative as with other alternatives, and the worst consequence accident is expected to be associated with one of the major DOE sites, the potential consequence of accidents could be greater because of the proximity of a larger population at many of the potential storage sites.

Figure 5-1. Summary of impacts for the No Action alternative. (The maximum incremental change from baseline is illustrated in graphs. Input data are summarized in Appendix K.)

The employment associated with SNF management at other generator/storage locations would be higher under this alternative than others because economies of scale would not be achievable with storage facilities being distributed among more than 50 sites. At the same time, however, non-SNF-related employment would decrease because of SNF management-related concerns. Several hundred reactor operations and research jobs could be lost if research reactors were forced to close because of the inability to store SNF onsite. This job loss is not represented in the SNF management employment consequences presented in Section 5.1.2.1.

Under the No Action alternative, no new research would be initiated on appropriate technologies for converting fuels to an acceptable form for ultimate disposition and no new facilities would be built over the next 40 years for that purpose. Because this research was not initiated, potential adverse environmental impacts associated with research activities were not assessed under the No Action alternative. The lack of adverse environmental impacts makes the No Action alternative appear to be more environmentally acceptable than the other alternatives, when in fact the adverse impacts cannot be assessed until the research projects are planned.

The sites that would be affected by the No Action alternative are the Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, naval sites, and other generator/storage locations. The environmental consequences at these sites are described below.

5.1.2.1 Socioeconomics.

As shown in Figure 5-1, the graph of the maximum incremental change in employment from SNF management activities for the major DOE sites, except the Idaho National Engineering Laboratory, indicates there would be little socioeconomic impact associated with the No Action alternative between 1995 and 2005. Implementation of the No Action alternative would result in the shutdown of the Expended Core Facility at the Idaho National Engineering Laboratory, resulting in the loss of approximately 500 permanent jobs from a region with a relatively low population and few jobs. Closure of the Expended Core Facility would initially result in an increase in direct employment at the facility by 50 jobs over 3 years to handle the transport of containers, but then the 500-person work force would decrease to a caretaker work force of 10 (see Appendix D, Volume 1). This results in the loss of an average of approximately 240 jobs over the 10-year period or 3 percent of the Idaho National Engineering Laboratory's work force, as shown in Figure 5-1. At the Hanford and Savannah River Sites, there would either be no change or less than a 1 percent increase in direct employment, respectively, from implementing the No Action alternative. The peak employment would be 50 additional workers at the Savannah River Site, approximately 0.3 percent of the 1995 baseline.

Naval sites would require very few additional workers to secure the naval SNF in storage and monitor its condition. The incremental labor required for SNF management at the naval sites would be drawn from the existing work force and would be insignificant with respect to current employment levels at those sites. At the university and other Government reactors, there would be a need for security and maintenance personnel for reactors that would shut down. While this would not be an increase in employment at those sites because the staff required to run the reactors would no longer be required, it would be an increase in the staff that would be involved directly in SNF management. Across all sites, there would be a decrease in employment of less than 0.1 percent of the total workforce. Therefore, implementation of the No Action alternative would have no socioeconomic effect on a nationwide scale.

5.1.2.2 Utilities (Electricity).

Figure 5-1 illustrates the maximum incremental power use with the No Action alternative in terms of percentage increase or decrease over baseline site use. For each of the sites, this change is very small and easily accommodated. Ongoing SNF operations are included in the baseline electric power usage, and the proposed actions under the No Action alternative are not power-intensive. At the Idaho National Engineering Laboratory, the shutdown of the Expended Core Facility would result in about a 5 percent reduction in electric power consumption below existing site usage. At naval and other generator/storage locations, there would be no discernable increase in power consumption over baseline use.

5.1.2.3 Materials and Waste Management.

Figure 5-1 illustrates the annual average volume of high-level, transuranic, and mixed wastes and low-level waste that would be generated from SNF management over the next 10 years under the No Action alternative. Day-to-day SNF management and storage activities would annually generate approximately 20 cubic meters per year (26 cubic yards per year) of transuranic wastes and approximately 400 cubic meters per year (520 cubic yards per year) of low-level waste at the Savannah River Site. These volumes would be generated by activities required to safely store SNF, including the onsite consolidation of existing fuels and refurbishment of existing SNF storage pools.
No high-level waste would be generated at any of the sites under the No Action alternative, and very small levels of all wastes would be generated by the Hanford Site and the Idaho National Engineering Laboratory.

At the naval sites, implementation of the No Action alternative would result in the production of limited amounts of solid municipal wastes and low-level radioactive waste. Wastes produced from the storage of naval SNF would be controlled and managed in accordance with existing site management programs. These small amounts of waste are shown as zero in Figure 5-1.

5.1.2.4 Radiological Impacts.

For the No Action alternative, the radiological impacts from normal operations and accident risks are expected to be small at each of the major DOE and naval sites that handle and store SNF. Radiological impacts from normal operations and accidents are discussed by site below.

Radiological Impacts From Normal Operations-The airborne releases from the SNF interim storage pools at the Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site were estimated to result in low-level exposures to the population in the vicinity of the site with no additional latent cancers within that population expected. For naval sites, there would be no airborne releases; direct radiation is the only mechanism of exposure associated with the dry SNF interim storage technologies that would be used under this alternative. The estimated annual latent cancer fatalities for the general population are illustrated in Figure 5-1.

Radiological Impacts From Accidents-

Hanford Site. Under the No Action alternative, a wide range of accident scenarios was considered, including accidents initiated by operational events, external hazards such as aircraft crashes, and natural phenomena such as earthquakes. The highest risk SNF-related accidents identified in Section 5.15 of Appendix A are a liquid metal (sodium) fire in the Fast Flux Test Facility fuel storage area (highest to general population) and a spent fuel cask drop at the 105-K Basin (highest to workers). Major seismically induced accidents were also identified in buildings containing SNF (324 Building and 325 Building). Releases from these buildings were associated with materials other than SNF and therefore are not discussed here. Aircraft-crash initiated accidents were not considered to be reasonably foreseeable because of their very low frequency.

For both of the SNF-related accidents identified, the probabilities of occurrence are estimated to be less than one chance in 10,000 per year of operation. The estimated population doses, using very conservative meteorology and assuming no protective action, for the Fast Flux Test Facility sodium fire accident corresponds to an estimated 37 latent cancer fatalities in the general population within 80 kilometers (50 miles). The estimated risk per year, taking into account the probability of occurrence of this accident, is less than 3.7 10-3 potential latent cancer fatalities in the general population.

The potential dose to the maximally exposed offsite individual corresponds to an estimated probability of a latent cancer fatality of 2.5 10-4 for the Fast Flux Test Facility sodium fire. Emergency actions would likely reduce the actual exposures to any offsite individuals.

An onsite worker at the maximum exposure location downwind of the spent fuel cask drop is estimated to receive doses that correspond to an estimated probability of a latent cancer fatality of 1.4 10-3. The estimated risk for a worker is 1.4 10-7 latent cancer fatalities per year.

Workers (up to 12) in the immediate vicinity of the cask drop accident could receive doses on the order of 70 to 140 rem (70,000 to 140,000 millirem). Acute doses of this magnitude are in the lower end of the range of doses that might produce symptoms of acute radiation syndrome in humans. For that accident, workers could be near the cask when it drops and receive direct radiation and inhale airborne fission products.

Potential secondary impacts identified for the Fast Flux Test Facility liquid metal fire (Table 5.15-2 of Appendix A) include temporary closure of the Hanford Reach of the Columbia River to boat traffic, temporary restriction of water use locally, possible loss of crops, environmental contamination in the vicinity of the facility and near offsite environs, potential restriction on land use for agriculture, temporary restriction on fishing access, and cleanup costs. The secondary impacts associated with the K Basin cask drop would be somewhat lower but similar in nature.

Idaho National Engineering Laboratory. Under the No Action alternative, a wide range of accident scenarios were also considered, including accidents initiated by operational events, external hazards such as aircraft crashes, and natural phenomena such as earthquakes. A number of SNF-related accidents are identified in Section 5.15 of Appendix B.

The highest risk to the general population is associated with the melting of a small number of assemblies as a result of a major earthquake and hot cell breach at the Hot Fuel Examination Facility. The estimated probability of this accident is about 1 chance in 100,000 per year of operation. General population consequences are estimated to be approximately 7 latent cancer fatalities, with an estimated risk of a latent cancer fatality of 7.0 10-5 latent cancer fatalities per year.

The highest risk to workers is an inadvertent nuclear criticality in the Idaho Chemical Processing Plant CPP-603 Underwater Fuel Storage Facility, which has an estimated probability of 1 chance in 1,000 per year of operation. The estimated probability of a latent cancer fatality in a worker approximately 100 meters (about 330 feet) downwind of the accident would be 3.9 10-5. The estimated risk for a worker is 4.0 10-8 latent cancer fatalities per year.

If workers were in the immediate vicinity, doses under some circumstances could be very high but are not likely to be fatal immediately. In the criticality accident, the criticality would occur under approximately 6.1 meters (20 feet) of water. Shielding by the water would be sufficient to prevent exposure of nearby workers. Expulsion of a cone of water above the criticality might lead to significant exposure to any workers who were directly above the location of the criticality.

Fuel-handling accidents have the highest estimated frequency of occurrence at 1.0 x 10-2 per year, but because of their lower consequences, fuel-handling accidents do not represent the highest risk accidents under the No Action alternative. The frequency of fuel-handling accidents is directly related to the amount of fuel handled and the annual number of SNF shipments projected under the alternative.

Potential secondary impacts identified (Table 5.15-8 of Appendix B) for the criticality accident at the Idaho Chemical Processing Plant are limited adverse effects to vegetation or wildlife and local contamination requiring cleanup around the accident site. More extensive contamination and impacts are expected should a cell breach occur at the Hot Fuels Examination Facility. Additional secondary impacts identified include the potential for a 1-year restriction in agricultural use of up to 10,000 acres on and off the Idaho National Engineering Laboratory site, the potential interdiction of affected agricultural products on nearby lands, and the potential for temporary restricted access to affected public land (less than 10,000 acres).

The Expended Core Facility at the Idaho National Engineering Laboratory would be shut down after a transition period of approximately 3 years. Potential accidents during this period are presented in Attachment F of Appendix D under the subheading of the Decentralization alternative.

Savannah River Site. Under the No Action alternative, a wide range of accident types and accident initiators were considered for the existing SNF wet storage activities, including accidents initiated by operational events, external hazards such as aircraft crashes, and natural phenomena such as earthquakes. Five types of SNF-related accidents are identified in Section 5.15 and Attachment A of Appendix C. These include (a) a fuel assembly breach because of dropping, objects falling onto the assembly, or accidental cutting into the fuel part of an assembly, (b) an inadvertent nuclear criticality in an SNF interim storage pool, (c) a fire and explosion in an adjacent facility, and (d) spills of contaminated storage pool water either within the storage facility or to the ground outside of the facility. The initiators for these accidents include both operational events and natural phenomena such as earthquakes. Aircraft-crash-initiated accidents were not considered to be reasonably foreseeable because of their very low frequency.

The highest risk accident, both to the general population and workers, was identified as the fuel assembly breach accident with an estimated frequency of 0.16 per year. The estimated population dose for this accident corresponds to 8.5 10-3 latent cancer fatalities in the general population within 80 kilometers (50 miles). The estimated risk, taking into account the probability of occurrence of this accident, is 1.4 10-3 latent cancer fatalities per year. The estimated dose to the maximally exposed offsite individual corresponds to an estimated probability of a latent cancer fatality of 1.6 10-7 per year.

A co-located worker downwind of the accident is estimated to receive a dose that corresponds to an estimated probability of 4.8 10-6 latent cancer fatalities. The estimated risk for a worker is 7.7 10-7 latent cancer fatalities per year.

Based on past experience at the Savannah River Site (two fuel cutting/breach accidents have occurred in the Receiving Basin for Offsite Fuels), no fatalities nor high exposures to facility workers are expected for this type of accident. This type of accident would likely occur with the assembly under 0.3 to 6 meters (1 to 20 feet) of water and result in small amounts of fuel and fission products being released to the pool water. The shielding effects of the pool water would attenuate most of the radiation released, but the noble gases released would rise to the surface of the water and enter the room atmosphere, causing a direct radiation exposure to workers in the area. Upon releases into the room's atmosphere, radiation alarms would sound requiring evacuation of nearby workers. Timely evacuation would likely prevent substantial radiation exposure.

Potential secondary impacts identified for the SNF-related accidents (Table 5-25 of Appendix C) are land contamination around the site of the accident, with minor contamination outside of the immediate facility area. This would not likely require cleanup of more than 4 hectares (10 acres).

Naval Facilities. Under the No Action alternative, newly generated SNF would be stored at naval sites, which differs from the historical practice of SNF management at the Idaho National Engineering Laboratory. The naval sites are generally located in densely populated areas. As a result, the consequences of an accident involving naval SNF at a naval site would be higher than the same accident at the Idaho National Engineering Laboratory.

After a limited transition period, naval SNF would be stored dry in shipping containers at Puget Sound, Pearl Harbor, Norfolk, and Portsmouth Naval Shipyards and the Kesselring Site. A review of a wide range of potential accidents (see Attachment F of Appendix D) indicated the limiting hypothetical accident scenario with the potential to release radioactive material from the storage containers was an airplane crash into the dry storage area. This accident is the highest risk accident for the general population and workers among all of the sites.

The highest risk to the general population occurs at Pearl Harbor. The probability of an aircraft crash at the Pearl Harbor facility is estimated to be 1 chance in 100,000 per year of operation. The estimated population consequences, using very conservative meteorology, is estimated to be 26 latent cancer fatalities in the general population within 80 kilometers (50 miles) of the site. The estimated risk to the general population, taking into account the probability of occurrence of this accident, is 2.6 10-4 latent cancer fatalities per year. The probability of a latent cancer fatality in the maximally exposed offsite individual is estimated to be 9.5 10-3.

The highest risk to workers occurs at Norfolk. The probability of an airplane crash at Norfolk is estimated to be 1 chance in 1,000,000 per year of operation. An onsite worker approximately 100 meters (about 330 feet) downwind of the accident is estimated to receive a dose that corresponds to a probability of a latent cancer fatality of 7.4 10-2. The estimated risk for a worker is 7.4 10-8 latent cancer fatalities per year.

It is not likely that any fatalities would occur in workers in the vicinity because workers are normally near the containers for only brief periods when a container is being placed in the dry storage array. At most, two or three nearby workers might receive significant radiation exposure from inhalation of airborne radioactivity if the container seal were breached. The low probability of the airplane crash itself, coupled with the probability that workers would be close enough to be affected, coupled with the probability that the wind would be blowing in the direction of the workers, makes it very unlikely that any worker would receive substantial radiation exposure.

Secondary impacts are principally land contamination around the site of the accident and temporary contamination of naval vessels at the shipyard. A total of approximately 43 hectares (106 acres) might require cleanup. The contamination could extend about 0.6 kilometers (0.4 miles) beyond the closest site boundary.

Other Generator/Storage Locations. Accident analyses were evaluated for these facilities. These accidents included (a) handling accidents that resulted in fuel drops with potential for fuel cladding breaches that could release portions of the more volatile fission products, such as noble gases and iodine, (b) accidental nuclear criticalities, (c) building collapse due to natural phenomena or external events such as major earthquakes or aircraft crashes, and (d) release of contaminated storage pool water. The analysis of these accidents indicated that they were similar in kind and consequence to those described for the major DOE sites and, therefore, these problems are not presented for each of the 57 other generator/storage locations. For the No Action alternative, no accidents related to SNF management were identified for the Nevada Test Site because no SNF is currently managed at the site. Two accidents were evaluated for the No Action alternative at the Oak Ridge Reservation. The first involved a dropped dam during refueling at the High Flux Isotope Reactor fuel pool. This accident resulted in an estimated 9.2 10-6 latent cancer fatalities to the worker and 1.7 latent cancer fatalities to the general population with a risk to the worker of 9.2 10-10 and to the general population of 1.7 10-4. A beyond design basis accident at the High Flux Isotope Reactor could result from a roof collapse triggered by a tornado. This accident could result in an estimated 2.0 10-2 latent cancer fatalities to the worker and 2.3 latent cancer fatalities to the general population with a risk to the worker of 3.8 10-9 and to the general population of 4.4 10-6.

5.1.2.5 Nonradiological Impacts.

A series of the maximum reasonably foreseeable accidents was evaluated at each of the SNF management sites that would potentially release hazardous or toxic chemicals to the workplace or the environment. The specific accident was defined and effects were estimated based on the characteristics of the specific facility, potentially affected public adjacent to the facility, and local residents (at the site boundary).

The maximum reasonably foreseeable chemical accident at SNF management facilities at the Hanford Site could result in the release of polychlorinated biphenyls and sulfuric acid at the 105-KE and 105-KW Basins. Should these releases occur, workers and the general public travelling adjacent to the accident could be subjected to chemical concentrations that might cause fatalities or serious health effects. The general public at the reservation boundary would be subjected to approximately 20 percent or less of the guideline value.

A maximum reasonably foreseeable chemical accident at the Idaho Chemical Processing Plant would be expected to release chlorine and nitric acid. Should such an event occur, workers would be subjected to chemical concentrations that might cause fatalities or serious health effects. The general public at the site boundary would be subjected to approximately 7 percent or less of the guideline value (Emergency Response Planning Guideline-3). The expected concentration on public access adjacent to the spill would be approximately 30 percent of the guideline value. Because these accidents would occur in each of the alternatives evaluated and do not discriminate among alternatives, they are not discussed further.

The release of nitrogen dioxide vapor from the interaction of target cleaning solution and sodium nitrite at the Receiving Basin for Offsite Fuel is the maximum reasonably foreseeable chemical accident at the Savannah River Site. Should this accident occur, the estimated concentration would be approximately 1 percent of the concentration that would be expected to cause fatalities or serious health effects for the worker and 0.1 percent for the maximally impacted offsite individual.

A diesel spill and fire was identified as the maximum reasonably foreseeable accident at each of the naval sites. Such an accident would be expected to produce toxic gas concentrations. Such an incident, should it occur, would be expected to cause fatalities or serious health effects from three chemicals (sulfur dioxide, oxides of nitrogen, and nitric acid) that are produced during the fire. Workers and the public on the nearest public access point at each of the five naval sites would be affected. The releases might also be expected to adversely affect the public immediately outside the facility boundary at the Norfolk Naval Shipyard site.

5.1.2.6 Transportation.

Shipments-Under the No Action alternative, the only offsite transportation of SNF involves shipments of naval SNF from the Newport News Shipyard to the Norfolk Naval Shipyard and shipments of irradiated test specimens from the Expended Core Facility at the Idaho National Engineering Laboratory to offsite locations. Onsite transportation of SNF would occur at the Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site.

Incident-Free Transportation-For the No Action alternative, the incident-free transportation of SNF was estimated to result in a total of 0.0089 fatalities over the 40-year period 1995 through 2035. These fatalities were the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions. The estimated number of radiation-related latent cancer fatalities for transportation workers was 0.0026, the estimated number of radiation-related cancer fatalities for the general population was 0.00032, and the estimated number of nonradiological fatalities from vehicular emissions was 0.0059.

Onsite shipments of SNF were estimated to result in 0.0022 fatalities. Offsite shipments of SNF were estimated to result in 0.0067 fatalities. These fatalities represent the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

Transportation Accidents-The cumulative transportation accident risks over the 40-year operational period were estimated to be 4.1 10-6 latent cancer fatalities and 0.047 traffic fatalities. If an accident occurred, it would be unlikely to result in the release of any radioactivity. The maximum reasonably foreseeable accident has a chance of occurrence between 1 10-6 and 1 10-7 per year. If it occurred in an urban or suburban population zone, the likelihood of a single latent cancer fatality within the exposed population was estimated to be about 1 in 100. In a rural population zone, the likelihood of a single latent cancer fatality was estimated to be about 1 in 500.

Onsite transportation of SNF would occur under the No Action alternative at the Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site. The maximum reasonably foreseeable accident for this alternative would occur at the Idaho National Engineering Laboratory, with a latent cancer fatality risk of about 7.5 10-7 for a rural population zone and about 1.1 10-5 for a suburban population zone. In the extremely unlikely event that this accident occurred under stable (worst-case) weather conditions, it could result in 6 latent cancer fatalities in a rural population, such as around the Idaho National Engineering Laboratory, within 80 kilometers (50 miles) of the accident, or 85 latent cancer fatalities in a suburban population zone. For comparison, the rural population zone would be expected to experience 350 cancer fatalities and the suburban population zone would experience 42,000 cancer fatalities from other causes.

5.1.3 Decentralization Alternative

Under the Decentralization alternative, SNF currently stored or generated at DOE sites would remain at those sites, and SNF generated by university, other Government reactors, and foreign research reactors would be transported to either the Idaho National Engineering Laboratory or the Savannah River Site. Special-case commercial SNF would be transported to the Idaho National Engineering Laboratory. Storage facilities would be upgraded or replaced at DOE sites to improve the safe and secure storage of SNF. Existing research and development of technologies improving the safe and secure storage of SNF at DOE sites would continue, and new projects would commence. The Navy would store SNF at or near the point of refueling or defueling (Option A), transport about 10 percent of its SNF to the Puget Sound Naval Shipyard for limited examinations and storage with the remainder stored at or near the point of fueling or defueling (Option B), or transport all naval SNF to the Expended Core Facility at the Idaho National Engineering Laboratory for examination and then transport it back to naval sites for storage (Option C).

The implications of this alternative would be the closure of the Expended Core Facility at the Idaho National Engineering Laboratory under Options A and B and the modification of an existing facility at Puget Sound Naval Shipyard to provide limited examination under Option B. Major DOE sites might build new storage facilities to replace existing facilities or to accept newly generated SNF from other sites. Degraded fuels at the major DOE sites might be stabilized to improve safe storage.

The sites affected by the Decentralization alternative include the Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, and naval sites. The environmental consequences at these sites are described below.

5.1.3.1 Socioeconomics.

For the Decentralization A and B options, one socioeconomic consequence would be similar to that described for the No Action alternative-closing the Expended Core Facility would result in the loss of an average of approximately 240 direct jobs over 10 years at the Idaho National Engineering Laboratory (Figure 5-2), with an ultimate loss of about 500 jobs. This represents a decrease in employment at the Idaho National Engineering Laboratory of approximately 6 percent. Under the Decentralization C option, the Expended Core Facility would continue to operate at the Idaho National Engineering Laboratory with no socioeconomic consequences. At the Hanford and Savannah River Sites, this alternative would result in significant new construction, employing an additional 80 to 640 workers at the Hanford Site and 200 to 220 workers at the Savannah River Site over a 10-year period depending on the options chosen for SNF management at those sites. The higher value reflects an increase above baseline site employment of approximately 3 percent at the Hanford Site and approximately 1 percent at the Savannah River Site. The peak in employment would be an additional 1,100 workers at the Hanford Site, approximately 6 percent of the 1995 baseline.

Figure 5-2. Summary of impacts for the Decentralization alternative. (The maximum incremental changefrom baseline is illustrated in all graphs. Input data are summarized in Appendix K).

Increases in construction activity over the short-term at the Hanford Site could strain the housing market and put additional demands on school capacity. Operations after the construction period would have very small consequences through the overall project timeframe. No secondary effects on the local community are expected at the Savannah River Site.

At the naval sites, the Decentralization alternative would require construction workers and laborers to construct fuel storage areas and to staff these areas, but it is expected that these workers would come from the sites or the local area, and there would not be a significant socioeconomic impact on the surrounding communities. Nevertheless, staff required would be approximately 1 percent increase over existing naval site staffing.

5.1.3.2 Utilities (Electricity).

Figure 5-2 illustrates the minimum and maximum incremental change in power use with respect to existing site usage from implementing the Decentralization alternative. As previously discussed in Section 5.1.1.2, the variation in power use by site shown on this graph reflects whether processing occurs or not. As an example, if the Hanford Site were to choose a storage option over a processing option, the power required for the storage option would be less than 1 percent of the overall site use; however, if a processing option were selected, then power use could increase to 37 percent above existing site use (see Appendix K). At each of the sites, the increase in electricity consumption could be accommodated with the existing site electric power infrastructure. At Hanford, if a processing option were selected, an extension of existing utilities in the 200 Area to the project area would be necessary. The maximum potential electricity usage shown at the Savannah River Site would be associated with the processing option that requires the operation of the F- and H-Canyons. These have operated for many years, and onsite and offsite utilities are adequate for their operation. At the Idaho National Engineering Laboratory, the principal differences among options are due to the operation or shutdown of the Expended Core Facility as was discussed in Section 5.1.2.2.

5.1.3.3 Materials and Waste Management.

The minimum and maximum volumes of high-level, transuranic, mixed, and low-level wastes that would be generated by SNF management activities over the next 10 years relative to the baseline are shown in Figure 5-2. The combined volume of high-level, transuranic, and mixed waste generated annually, if processing options were implemented, is estimated to average from approximately 18 to 44 cubic meters per year at the Savannah River Site and Hanford Site, respectively. In contrast, if wet storage options for N-Reactor fuel were selected at the Hanford Site then no high-level, transuranic, or mixed waste would be expected to be generated. Figure 5-2 also illustrates the volume of low-level waste that would be generated from implementation of the Decentralization options. It should be noted that the volume of low-level waste would increase if a processing option were selected at either the Hanford Site or the Savannah River Site. Additional volumes of low-level waste would be generated at the Savannah River Site from the limited receipt of SNF shipments from offsite and by the addition of a new canning facility. Low-level waste would only be generated at the Idaho National Engineering Laboratory under the Decentralization alternative, where the Expended Core Facility would continue to operate. Operation of an Expended Core Facility could result in the annual production of approximately 430 cubic meters (526 cubic yards) of low-level waste (Appendix D).

At the naval sites, the implementation of the Decentralization alternative would have the same impact as that described in Section 5.1.2.3 for the No Action alternative because interim storage would be at the naval sites under both alternatives.

5.1.3.4 Radiological Impacts.

Radiological exposures to both workers and the public from normal operations for the Decentralization alternative were estimated to be small, similar to the No Action alternative, with the principal differences associated with possible implementation of the processing options at the Hanford and Savannah River Sites because of higher radionuclide releases to the atmosphere. This increases the offsite population doses and potential for latent cancer fatalities. Figure 5-2 illustrates the estimated latent cancer fatalities associated with SNF operations at the major sites. The estimated latent cancer fatalities from 40 years of SNF operation would be less than one for each site.

Hanford Site-The Decentralization alternative considers several options for construction of new facilities at the Hanford Site, including a new wet storage facility for N-Reactor SNF and a new dry storage facility for fuels currently stored at other onsite locations. A second option for implementation of the Decentralization alternative at the Hanford Site is processing of the N-Reactor SNF followed by dry storage.

Under this alternative, one of the highest risk SNF-related accidents identified for the No Action alternative remains-the spent fuel cask drop at a wet storage facility. Because of the locations of the new storage facility, the offsite consequences and risks associated with this accident could be reduced to 25 percent of those described under the No Action alternative. The other highest risk accident, the sodium fire in the Fast Flux Test Facility fuel storage area, is no longer applicable because the Fast Flux Test Facility SNF would be moved to a new dry storage facility.

Potential accidents at the proposed new facilities include a severe cask impact followed by a fire at a new dry storage facility and a uranium metal fire at a new facility for processing N-Reactor SNF. Appendix A indicates that the cask impact and fire accident scenario presents the highest estimated risk to both the onsite workers and the general public of the accident scenarios identified for this alternative at Hanford.

For the severe cask impact accident, the estimated probability is 6 in 1,000,000 per year of operation. The estimated population dose, using very conservative meteorology, corresponds to 81 latent cancer fatalities in the general population within 80 kilometers (50 miles). The estimated risk per year, taking into account the chance of occurrence of this accident, would be 4.9 10-4 latent cancer fatalities per year in the general population. The potential dose to the maximally exposed offsite individual, assuming no protective action, corresponds to an estimated probability of a latent cancer fatality of 2.5 10-4.

An onsite individual approximately 100 meters (about 330 feet) downwind of the accident who remains within the plume while the fire burns could receive a dose of 120 rem (120,000 millirem). Acute doses of this magnitude are in the lower end of the range of doses that might produce symptoms of acute radiation syndrome in humans. Because a fire is also involved, the close-in dose is highly dependent on the meteorological conditions at the time, the amount of plume rise that is generated by the heat from the fire, the exact location of the accident relative to buildings, etc. An individual 100 meters (about 330 feet) downwind is estimated to receive a dose that is sufficient to cause immediate health impacts, but probably would not be lethal. This dose corresponds to an estimated worker probability of a latent cancer fatality of 9.4 10-2. The estimated risk for a worker is 5.6 10-7 latent cancer fatalities per year.

Workers in the immediate vicinity of this accident could receive very high doses that could be lethal unless they immediately evacuated the area of the accident. There are likely to be two time scales for releases associated with this accident: immediately following the accident and while the fire burns. Nearby workers may not be able to avoid the immediate radiological impacts but could likely evacuate the area and avoid most of the fire-related radiological releases unless incapacitated by the accident.

Potential secondary impacts identified for the severe cask impact with fire accident (Table 5.15-2 of Appendix A) include possible restriction of use of the Hanford Reach of the Columbia River for recreation, potential loss of crops, moderate environmental contamination in the vicinity of the facility and near offsite environs, temporary restriction on land use for agriculture, possible short-term restriction on fishing access, and cleanup costs.

Idaho National Engineering Laboratory-Under the Decentralization alternative at the Idaho National Engineering Laboratory the highest consequence and highest risk SNF-related accidents are associated with SNF storage and are the same as described under the No Action alternative. Under the Decentralization alternative, there are more SNF shipments, and consequently more handling of SNF compared to the No Action alternative. As a result, the potential frequency of fuel-handling accidents could be about 20 percent higher than under the No Action alternative, but because of lower consequences, fuel-handling accidents would not represent the highest risk accidents under the Decentralization alternative (see DOE-ID 1994).

Savannah River Site-The Decentralization alternative considers several options for SNF management at the Savannah River Site, including wet storage (Option 2b), new facilities for dry storage (Option 2a), and processing the SNF followed by dry storage (Option 2c), which were not considered under the No Action alternative.

The highest risk accident for both the general population and workers, however, would be the fuel assembly breach accident that was discussed under the No Action alternative.

The accident frequency is expected to be about 0.35 fuel assembly breaches per year of operation with implementation of this alternative. The risks to the general public, the maximally exposed offsite individual, and co-located workers were estimated to be 3 10-3, 3.5 10-7, and 1.7 10-6 latent cancer fatalities per year of operation, respectively.

Naval Facilities-The accident risks for the three subalternatives were evaluated for the naval facilities under the Decentralization alternative: (a) decentralization with SNF retained at the shipyards and the Kesselring Site without examination of the SNF, (b) decentralization with limited examination at Puget Sound Naval Shipyard, and (c) decentralization with performance assessment examination at the Expended Core Facility at the Idaho National Engineering Laboratory followed by storage at naval sites. Attachment F of Appendix D presents a full discussion of the accident risks at each of the naval sites.

The accident risks associated with this alternative would be the same as with the No Action alternative, with the highest risk accident being an aircraft crash into a dry storage container. The consequences and risks of this maximum risk accident would be the same as those described under the No Action alternative.

Other Generator/Storage Locations-For the Decentralization alternatives, the accident risks at the Oak Ridge Reservation and other SNF interim storage sites that do not transport their SNF elsewhere would be expected to be similar to and bounded by the accident risks under the No Action alternative.

5.1.3.5 Nonradiological Accidents.

The maximum reasonably foreseeable chemical accident at the Idaho National Engineering Laboratory, Savannah River Site, naval sites, and other generator/storage locations would be similar to those described under the No Action alternative. An accident at the wet storage facility on the Hanford Site could release sulfuric acid vapor and subject workers to up to 130 percent of the chemical concentrations that are associated with fatalities or serious health effects.

5.1.3.6 Transportation.

Shipments-Under the Decentralization alternative, university, foreign, and non-DOE research reactors would transport SNF to the Idaho National Engineering Laboratory and the Savannah River Site. In addition, naval SNF shipments would be equal to or greater than those under the No

Action alternative, depending on the choice of subalternative with respect to fuel examination options. Onsite shipments at major DOE sites would occur to relocate SNF from one facility to another for stabilization or storage.

Incident-Free Transportation-For the Decentralization alternative, the incident-free transportation of SNF was estimated to result in total fatalities that ranged from 0.12 to 0.38 over the 40-year period 1995 through 2035. These fatalities represent the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

The reason for a range of fatalities was because of three factors: (a) different examination options for naval SNF (see Appendix D), (b) the option of using truck or rail transport for DOE SNF (see Appendix I), and (c) different SNF management options at the Savannah River Site (see Appendix C). Navy shipments would be made using a combination of truck and rail; DOE shipments were assumed to be made using 100 percent truck or 100 percent rail.

The estimated number of radiation-related latent cancer fatalities for transportation workers ranged from 0.026 to 0.090, the estimated number of radiation-related latent cancer fatalities for the general population ranged from 0.041 to 0.24, and the estimated number of nonradiological fatalities from vehicular emissions ranged from 0.047 to 0.050 for this alternative.

Onsite shipments of SNF were estimated to result in 0.0025 to 0.0036 fatalities. Offsite shipments of SNF were estimated to result in 0.12 to 0.37 fatalities. These fatalities also represent the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

Transportation Accidents-The cumulative transportation accident risks over the 40-year operational period were estimated to be in the range of 0.00085 to 0.0009 latent cancer fatalities, and 0.20 to 1.01 traffic fatalities, if all SNF were transported by truck. If all SNF were transported by rail, the corresponding risks were estimated to be in the range of 0.00029 to 0.00034 latent cancer fatalities, and 0.26 to 1.07 traffic fatalities. The range of fatality estimates reflects the different fuel examination options for naval SNF (see Appendix D).

The maximum reasonably foreseeable offsite transportation accident under the Decentralization alternative involves transport of naval SNF by rail in a suburban area. The consequences of such an accident were estimated to be 1.7 latent cancer fatalities. The probability of occurrence of such an accident would be slightly greater than 1.0 10-7 per year. This probability accounts for the accident rate per mile traveled, the number of miles traveled, the percentage of the total distance that occurs in a suburban area, the meteorological conditions, and the severity of the accident. Based on DOE guidance (DOE 1993b), accidents with a probability of occurrence less than 1.0 10-7 per year are not reasonably foreseeable and are not evaluated in this EIS. Consistent with this guidance, an accident of similar severity to that above for the suburban area, but occurring in an urban area, would not be reasonably foreseeable. This is because the total miles traveled in an urban area would be only a few percent of the total transportation route, resulting in a probability of occurrence of less than 1.0 10-7 per year. Thus, the maximum reasonably foreseeable offsite transportation accident in an urban area would be less severe than postulated to occur in a suburban area and is estimated to result in 0.065 latent cancer fatalities. (A more complete discussion of this apparent anomaly is presented in Section A.5.2 of Volume 1, Appendix D, Part B, Attachment A.)

Onsite transportation of SNF would occur under the Decentralization alternative at the Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site. The maximum reasonably foreseeable accident for this alternative occurs at the Idaho National Engineering Laboratory, and the potential impacts would be the same as those described under the No Action alternative.

5.1.4 1992/1993 Planning Basis Alternative

Under the 1992/1993 Planning Basis alternative, SNF currently stored at major DOE sites would remain at those sites, and newly generated SNF from DOE, university, and other Government reactors would be transported to the Idaho National Engineering Laboratory or the Savannah River Site for storage. Special-case commercial SNF and naval SNF would be transported to the Idaho National Engineering Laboratory for storage. Existing research and development of technologies improving the safe and secure storage of SNF at DOE sites would continue, and new projects would commence. Examination of naval fuels would be conducted at the Expended Core Facility at the Idaho National Engineering Laboratory.

The implications of this alternative for major DOE sites would be similar to those described for the Decentralization alternative. New storage facilities would be built at the major DOE sites to replace existing facilities or to accept newly generated SNF from other sites. Degraded fuels at the Savannah River Site and the Hanford Site might be stabilized to improve safe storage.

The sites that would be affected by the 1992/1993 Planning Basis alternative are the Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site. The environmental consequences at these sites are described below.

5.1.4.1 Socioeconomics.

Implementation of the 1992/1993 Planning Basis alternative would not have a significant socioeconomic impact at any of the major DOE or naval sites (Figure 5-3). The impacts at the Hanford and Savannah River Sites would be similar to those described for the Decentralization alternative in Section 5.1.3.1 and shown on Figure 5-2. Proposed new construction and maintenance activities at the Idaho National Engineering Laboratory would result in the addition of approximately 130 workers over 10 years, less than a 2 percent increase above baseline site employment. The peak employment at Hanford would be the same as that described for the Decentralization alternative, a maximum of about 1,100 additional workers at the Hanford Site, an increase of approximately 6 percent above the 1995 baseline. Secondary socioeconomic impacts at the Hanford Site would be similar to those described under the Decentralization alternative.

There would be no socioeconomic impact at the naval sites because current practices would not be altered. Storage facilities would not need to be constructed at the individual naval sites, and no employment would be generated at naval sites.

5.1.4.2 Utilities (Electricity).

The minimum and maximum change in power use from implementing the 1992/1993 Planning Basis alternative with respect to the site baseline is shown in Figure 5-3. The impact on power consumption at the sites would be the same as that described for the Decentralization alternative in Section 5.1.3.2 (compare with Figure 5-2) except at the Idaho National Engineering Laboratory. The variation in power use over site baseline use at the Savannah River and Hanford Sites reflects whether a storage or processing option is selected for SNF management. The increase in power use at the Idaho National Engineering Laboratory would be because of the Electrometallurgical Process Demonstration Project. If processing options were implemented at the Hanford Site, an extension of existing utilities to the project area would be necessary.

Figure 5-3. Summary of impacts for the 1992/1993 Planning Basis alternative. (The maximum incremental change from baseline is illustrated in all graphs. Input data are summarized in Appendix K).

5.1.4.3 Materials and Waste Management.

Figure 5-3 illustrates the combined average annual volumes of high-level, transuranic, and mixed wastes and of low-level wastes that would be generated over the next 10 years as a result of SNF management activities with the implementation of the 1992/1993 Planning Basis alternative. The volume of low-level waste and the combined volume of high-level, transuranic, and mixed waste would be similar to the volumes generated under the Decentralization alternative for the Hanford and Savannah River Sites (see Figures 5-2 and 5-3). The minimum and maximum values shown for these sites reflect whether a storage option or a processing option would be implemented, respectively.

At the Idaho National Engineering Laboratory, implementation of the 1992/1993 Planning Basis alternative would result in the generation of high-level, transuranic, and mixed wastes. These wastes would be generated by the Electrometallurgical Process Demonstration Project. The volume of low-level waste generated at the Idaho National Engineering Laboratory would be from the construction and operation of new storage and characterization facilities at the site. Adequate storage capacity exists at the site for these wastes until 2005, when additional capacity would be expected to be required for managing low-level waste (Appendix B).

5.1.4.4 Radiological Impacts.

Radiological exposures to both workers and the public from normal SNF management operations and onsite accidents for the 1992/1993 Planning Basis alternative would be essentially the same as estimated for the Decentralization option. Figure 5-3 illustrates the estimated latent cancer fatalities associated with SNF operations at the major sites.

SNF Facility Accidents-

Hanford Site. The implementation of the 1992/1993 Planning Basis alternative at the Hanford Site would not result in accident risks significantly different from those identified for the Decentralization alternative (Section 5.15 of Appendix A).

Idaho National Engineering Laboratory. Under the 1992/1993 Planning Basis alternative at the Idaho National Engineering Laboratory, the consequences and risks of accidents associated with SNF storage would be the same as described under the No Action alternative (Section 5.15 of Appendix B). The consequences of fuel-handling accidents would be the same as described under the No Action alternative, but increased SNF shipments, and consequently more handling of SNF, could result in a frequency of fuel-handling accidents about three times higher than for the No Action alternative (Slaughterbeck et al. 1995). Because of the increased frequency of fuel-handling accidents, risk to the public from fuel-handling accidents may exceed the risk from SNF storage accidents.

Savannah River Site. The implementation of the 1992/1993 Planning Basis alternative at the Savannah River Site would not result in accident consequence estimates that differ from those identified under the Decentralization alternative (Section 5.15 and Attachment A of Appendix C). Because of increases in amount of SNF handled, the accident frequencies would be expected to increase.

The accident frequency for the highest risk accident, the fuel assembly breach, would be expected to be about 0.40 fuel assembly breaches per year of operation with implementation of this alternative. This results in estimated risk to the general public, maximally exposed offsite individual, and co-located worker of 3.4 10-3, 4.0 10-7, and 1.9 10-6 latent cancer fatalities per year of operation, respectively.

Naval Facilities. With implementation of the 1992/1993 Planning Basis alternative for naval facilities, all storage and examination activities occur at the Idaho National Engineering Laboratory. The maximum risk accident at this facility was not the maximum risk accident at the Idaho National Engineering Laboratory, so it is not discussed further in this volume. See Attachment F of

Appendix D for details.

Other Generator/Storage Locations. For the 1992/1993 Planning Basis alternative, the accident risks at the Oak Ridge Reservation and other SNF interim storage sites that do not transport their SNF elsewhere would be similar to the accident risks under the No Action alternative.

5.1.4.5 Nonradiological Accidents.

The maximum reasonably foreseeable chemical accident at the Idaho National Engineering Laboratory, Savannah River Site, and other generator/storage locations would be similar to those described under the No Action alternative. The Hanford Site accidents would be similar to those in the Decentralization alternative.

Two independent accidents were evaluated to describe the maximum reasonably foreseeable chemical hazards during the operation of the Expended Core Facility at the Idaho National Engineering Laboratory. Such a release could subject workers to chemical concentrations that could cause fatalities or serious health effects but would not subject the public to such concentrations.

5.1.4.6 Transportation.

Shipments-Under the 1992/1993 Planning Basis alternative, university, foreign, and non-DOE research reactors would transport SNF to the Idaho National Engineering Laboratory and the Savannah River Site. Commercial SNF stored at the West Valley Demonstration Project and graphite SNF stored at the Fort St. Vrain site would be transported to the Idaho National Engineering Laboratory. DOE research reactor SNF stored at various DOE sites would be transported to the Idaho National Engineering Laboratory and the Savannah River Site. Naval SNF would be transported from naval shipyards to the Expended Core Facility and irradiated test specimens would be transported between the Expended Core Facility and offsite locations. Onsite transportation would relocate SNF from one facility to another for stabilization or storage.

Incident-Free Transportation-For the 1992/1993 Planning Basis alternative, the incident-free transportation of SNF was estimated to result in total fatalities that ranged from 0.14 to 0.45 over the 40-year period 1995 through 2035. These fatalities were the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

The reason for a range of fatalities was due to two factors: (a) the option of using truck or rail transport for DOE SNF (see Appendix I) and (b) different SNF management options at the Savannah River Site (see Appendix C). Navy shipments would be made using a combination of truck or rail; DOE shipments were assumed to be made using 100 percent truck or 100 percent rail.

The estimated number of radiation-related latent cancer fatalities for transportation workers ranged from 0.029 to 0.11, the estimated number of radiation-related latent cancer fatalities for the general population ranged from 0.044 to 0.30, and the estimated number of nonradiological fatalities from vehicular emissions ranged from 0.045 to 0.071.

Onsite shipments of SNF were estimated to result in 0.0028 to 0.0036 fatality. Offsite shipments of SNF were estimated to result in 0.14 to 0.45 fatality. These fatalities were also the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

Transportation Accidents-The cumulative transportation accident risks over the 40-year operational period were estimated to be 0.0010 latent cancer fatality and 0.70 traffic fatality if all SNF were transported by truck. If all SNF were transported by rail, the corresponding risks were estimated to be 0.00035 latent cancer fatality and 0.73 traffic fatality.

The maximum reasonably foreseeable offsite transportation accident involves a rail shipment of special-case commercial SNF in a suburban population zone under neutral (average) weather conditions. The accident has a probability of occurrence of about 2.0 10-7 per year and would result in an estimated 7 latent cancer fatalities in the exposed population. For comparison, the same population would be expected to experience about 100,000 cancer fatalities from other causes. The probability of this accident occurring in an urban population zone would be less than 1 10-7 per year. In a rural population zone, the accident consequences would be estimated to be about 0.2 latent cancer fatalities.

Onsite transportation of SNF would occur under the 1992/1993 Planning Basis alternative at the Hanford Site, the Idaho National Engineering Laboratory, and the Savannah River Site. The maximum reasonably foreseeable accident for this alternative occurs at the Idaho National Engineering Laboratory, and the potential impacts would be the same as those described under the No Action alternative.

5.1.5 Regionalization Alternative

There are two alternatives under Regionalization: Regionalization 4A would relocate SNF according to fuel type; Regionalization 4B would relocate SNF according to location.

Under Regionalization 4A, certain types of SNF from other DOE sites, and SNF from university and other Government reactors, special-case commercial SNF, and foreign research reactor SNF would be transported to either the Idaho National Engineering Laboratory or Savannah River Site for storage. Existing research and development of technologies improving the safe and secure storage of SNF at DOE sites would continue, and new projects would commence. Naval SNF would be examined at the Expended Core Facility at the Idaho National Engineering Laboratory, then stored at the Idaho Chemical Processing Plant.

The implications of Regionalization 4A are essentially the same as those of the 1992/1993 Planning Basis alternative because there would be minor differences in the amounts of fuel transported to each destination under these alternatives (see Figure 5-4).

Under Regionalization 4B, however, two regional sites would be selected, and SNF would be moved to one site or the other. In the west, either the Hanford Site, Idaho National Engineering Laboratory, or Nevada Test Site would be the regional site; in the east, either the Savannah River Site or Oak Ridge Reservation would be designated. SNF stored or generated west of the Mississippi River would be transported to the Western Regional Site, and SNF stored or generated east of the Mississippi River would be transported to the Eastern Regional Site. An expended core facility would be built at either the Eastern or Western Regional Site (unless the Western Regional Site were the Idaho National Engineering Laboratory, in which case no new facility would be required). Research and development would be conducted at the regional sites.

Regionalization 4B affects more sites than Regionalization 4A. Only one site would have SNF management responsibility in the east and in the west; thus, SNF management activities would be phased out at those sites not selected as regional sites. If the Idaho National Engineering Laboratory were not selected as the Western Regional Site, the Expended Core Facility in Idaho would be closed, and a new facility would be built at either the Eastern or Western Regional Site. If the Oak Ridge Reservation were chosen as the Eastern Regional Site, SNF now at Savannah River would be transported to the Oak Ridge Reservation. This would require the development of new storage facilities at the Reservation. Some fuels might need to be stabilized before transport. If the Savannah River Site were selected as the Eastern Regional Site, there would be few differences between Regionalization 4B and Regionalization 4A except that an expended core facility might be built at the site. In the west, transport of Hanford SNF to another site would require stabilization of the N-Reactor fuels, the great majority of the SNF now stored there. Some Idaho National Engineering

Laboratory fuels would also require stabilization if they were transported to another site. New SNF management facilities would be required at any Western Regional Site selected because of the large volumes of SNF that would be received.

Figure 5-4. Summary of impacts for Regionalization 4A (by fuel type). (The maximum incremental change from baseline is illustrated in all graphs. Input data are summarized in Appendix K.)

This alternative would affect only the five major DOE sites. The environmental consequences at these sites are described below.

5.1.5.1 Socioeconomics.

Under Regionalization 4A, the socioeconomic impacts at the Idaho National Engineering Laboratory would be the same as those described for the 1992/1993 Planning Basis alternative described in Section 5.1.4.1. The peak employment under Regionalization 4A would be an additional 470 workers at the Hanford Site, approximately 3 percent above the 1995 baseline. Implementation of Regionalization 4A would have no socioeconomic consequences at either the Oak Ridge Reservation or the Nevada Test Site because this would result in no changes to existing operations at either site.

Impacts of Regionalization 4A on the naval sites would be the same as that described for the 1992/1993 Planning Basis alternative because naval SNF would be transported to the Expended Core Facility in Idaho for examination and storage at the Idaho National Engineering Laboratory.

If either the Hanford Site, Idaho National Engineering Laboratory, or Savannah River Site were not selected as a regional site under Regionalization 4B, there would be an eventual reduction in employment equal to existing employment for SNF management at these sites. This would add to the currently predicted loss of jobs at each of these sites. In the short term, additional jobs would be required to prepare SNF for transport offsite (see Figure 5-5). The closure of the Expended Core Facility at the Idaho National Engineering Laboratory, however, would lead to a short-term loss of jobs as well, increasing the rate of job loss at that site.

Sites that were selected as regional sites would have generally increased employment over baseline levels (see Figure 5-6). Site employment levels would also increase at whatever site an expended core facility were constructed (Figure 5-7). Employment at the Oak Ridge Reservation and Nevada Test Site would increase if these sites were chosen as the Eastern and Western Regional Sites. Operation of storage facilities at both the Oak Ridge Reservation and Nevada Test Site could ultimately result in the creation of approximately 500 jobs per year at both sites, a 3-percent increase above current site employment at Oak Ridge Reservation and a 6-percent increase above current site employment at the Nevada Test Site without the expended core facility or a 7- and 13-percent increase with an expended core facility, respectively (Figure 5-6). The peak annual employment from implementation of Regionalization 4B would be an additional 1,100 workers at the Nevada Test Site. The secondary impacts of increased employment at either the Oak Ridge Reservation or the Nevada Test Site could result in an increased housing demand. At the Nevada Test Site, overall socioeconomic impacts could be absorbed within the projected expansion of the local economy, infrastructure, public service, and real estate development. At the Oak Ridge Reservation, increased employment could result in increases in capital expenditures to meet the increased demand of housing, transportation, and educational facilities.

Figure 5-5. Summary of impacts for Regionalization 4B (by geography) if the site were not selected as the regional site. (The maximum incremental change from baseline is illustrated in all graphs. Input data summarized in Appendix K.)

Figure 5-6. Summary of impacts for Regionalization 4B (by geography) if sites were selected as a regional site and do not have the expended core facility. (The maximum incremental change from baseline is illustrated in all graphs. Input data are summarized in Appendix K.)

Figure 5-7. Summary of impacts for Regionalization 4B (by geography) if sites were selected as a regional site and have the expended core facility. (The maximum incremental change from baseline is illustrated in graphs. Input data are summarized in Appendix K.)

For the naval sites, implementing Regionalization 4B would have no socioeconomic consequences.

5.1.5.2 Utilities (Electricity).

As shown in Figure 5-4, implementing Regionalization 4A would have a similar impact on power consumption as the 1992/1993 Planning Basis alternative (compare Figures 5-3 and 5-4). There would be no effect on power consumption at the Oak Ridge Reservation, Nevada Test Site, or naval sites from the implementation of Regionalization 4A.

Figures 5-5, 5-6, and 5-7 illustrate the minimum and maximum change from baseline site power use from implementing Regionalization 4B with and without an expended core facility and if the site were not selected as the regional site. Regionalization at the Hanford Site or the Nevada Test Site could produce an impact on power consumption at these sites.

Figure 5-5 illustrates the impact on power consumption if a site were not selected as a regional site. The increase in electricity consumption at the Hanford Site and the Savannah River Site reflects the power required to prepare or process the SNF for transport as required. The decrease in power consumption at the Idaho National Engineering Laboratory would be from shutdown of the Expended Core Facility.

Figure 5-6 shows the minimum and maximum percent change, without an expended core facility, over baseline site power consumption if a site were selected as a regional center. At the Hanford Site and Savannah River Site, the power consumption increases slightly with the transport of naval fuel to the site. Regionalization at the Oak Ridge Reservation would result in a small (less than 3 percent) increase in electric power demand. The site electricity supply at each of these sites would be more than adequate. However, regionalization at the Nevada Test Site would increase power consumption about 13 percent above existing site usage and may require additional transmission lines or another substation at the site (see Appendices F and K).

Regionalization 4B with an expended core facility onsite is illustrated in Figure 5-7. The electricity requirements at each of the major DOE sites would increase with the addition of an expended core facility for examination of naval SNF. Power consumption at the Nevada Test Site would increase approximately 18 percent above baseline and about 40 percent at Hanford if the processing (figure maximum) option were selected. The storage only options (figure minimum) at the Hanford site would result in only a 3-percent increase in electricity consumption. The Nevada Test Site would require additional transmission lines or another substation to handle additional loads. The increased load could be handled at the Savannah River Site, and relatively minor increases could occur at the Idaho National Engineering Laboratory.

5.1.5.3 Materials and Waste Management.

Figures 5-4 through 5-7 illustrate the effects of implementing the different Regionalization alternatives: Regionalization 4A, Regionalization 4B with SNF transported offsite, Regionalization 4B without an expended core facility located at the selected site, and Regionalization 4B with an expended core facility located at the selected site. The annual average waste volumes generated from SNF management activities at a nonselected site would decrease over the next 10 years, but at the selected sites the annual generation rate of waste from SNF management activities would increase with implementation of the Regionalization alternative. The construction of an expended core facility at any site would also increase the annual volume of low-level waste generated.

The annual waste volumes generated from SNF management activities associated with Regionalization 4A are illustrated in Figure 5-4. The effects of Regionalization 4A would be similar to those described for the 1992/1993 Planning Basis alternative in Section 5.1.4.3 (see Figures 5-3 and 5-4).

Figure 5-5 illustrates the effect of not being selected as a regional center. In comparison to the Decentralization and 1992/1993 Planning Basis alternatives, the annual generation rate of high-level, transuranic, mixed, and low-level wastes would ultimately decrease at the affected site because the SNF inventory would be transported offsite. However, characterization and stabilization activities prior to transport would generate transient increases in waste volumes.

The effect of being selected as a regional center without a replacement expended core facility is illustrated in Figure 5-6. Implementation of this Regionalization 4B alternative would have similar effects at the Hanford Site and Savannah River Site as the 1992/1993 Planning Basis alternative. The Oak Ridge Reservation and Nevada Test Site would generate waste from SNF management activities under the alternative. Regionalization at either of these two sites would be expected to generate approximately 16 cubic meters (21 cubic yards) of transuranic waste and approximately 200 cubic meters (260 cubic yards) of low-level waste annually from operating an SNF management complex.

Figure 5-7 illustrates the effect on annual waste volume generation of being selected as a regional center with the addition of an expended core facility to examine naval SNF. The addition of the expended core facility would have no effect on the annual volume of high-level, transuranic, or mixed waste generated, but would increase the volume of low-level waste that would have to be managed at any site.

The effects from implementing either of the Regionalization alternatives at the naval sites would be the same as that described for the 1992/1993 Planning Basis alternatives in Section 5.1.4.3.

5.1.5.4 Radiological Impacts.

Radiological exposures to both workers and the public for Regionalization 4A would to be similar to the 1992/1993 Planning Basis alternative. These are not discussed further in this section. Figure 5-4 illustrates the potential latent cancer fatalities to the population within 80 kilometers (50 miles) from SNF operations at the major sites for Regionalization 4A.

Radiological exposures to both workers and the public for Regionalization 4B would to be similar to the 1992/1993 Planning Basis alternative if the Savannah River Site, Idaho National Engineering Laboratory, or Hanford Site were selected as regional sites. Figures 5-5, 5-6, and 5-7 illustrate the potential latent cancer fatalities to the population within 80 kilometers (50 miles) from SNF operations for Regionalization 4B if SNF is transported offsite, or if the site is selected as the regional site without and with the expended core facility, respectively.

For any of the Regionalization alternatives, the maximum estimated latent cancer fatalities in the general population from normal operations are estimated to be 7.6 10-3 per year.

SNF Facility Accidents-

Hanford Site. Accident risks under Regionalization 4A are the same as those for the Decentralization alternative. The selection of the Hanford Site as the regional site would not result in accident risks significantly different from those identified for the Decentralization alternative (Section 5.15 of Appendix A), although higher activity under this alternative would increase the annual frequency of accidents. The probability of the cask impact and fire accident scenario was estimated to be 7 in 1,000,000 if the Hanford Site were selected as a regional site.

Selecting a different site as the regional site would reduce the estimated accident risks from those identified for the Decentralization alternative because the existing wet storage facilities would be shut down and the amount of SNF handled at the dry storage facility would change slightly. The accident probability for the dry storage cask impact and fire was estimated to be 5 in 1,000,000 such that the estimated risk from this, the highest risk accident, would be 4.1 10-4 latent cancer fatalities in the general population per year of operation.

Idaho National Engineering Laboratory. While the consequences of potential SNF storage and handling accidents would be similar for all alternatives, the estimated frequency of handling accidents depends on the amount of SNF handled under the alternatives. For alternatives where all stored SNF is transported to another site, SNF storage and handling risks would be reduced to those associated with SNF generated at the Idaho National Engineering Laboratory research reactors. Under Regionalization 4A, the consequences and risks of accidents associated with SNF storage would be the same as described under the No Action alternative (Section 5.15, Appendix B). The consequences of fuel-handling accidents would be the same as described under the No Action alternative, but increased transporting and handling of SNF would result in a frequency of fuel-handling accidents about five times higher than for the No Action alternative (Slaughterbeck et al. 1995). Because of the increased frequency of fuel-handling accidents, risk to the public from fuel-handling accidents may exceed the risk from SNF storage accidents.

If the Idaho National Engineering Laboratory were selected as a regional site under Regionalization 4B, the highest consequences to the offsite population result from accidents involving stored SNF and would be the same as described under the No Action alternative (Section 5.15 of Appendix B). With the resumption of processing at the Idaho Chemical Processing Plant, the postulated accident with the highest consequence and risk to workers would be an inadvertent nuclear criticality during processing that has an estimated probability of 1 chance in 1,000 per year of operation. The estimated probability of a latent cancer fatality in a worker approximately 100 meters (330 feet) downwind of the accident would be 3.6 x 10-3, corresponding to an estimated risk to a worker of 3.6 x 10-6 latent cancer fatalities per year of operation. The consequences of fuel-handling accidents would be the same as described under the No Action alternative, but increased transporting and handling of SNF results in a frequency of fuel-handling accidents about 20 times higher than for the No Action alternative (Slaughterbeck et al. 1995). Because of the increased frequency of fuel-handling accidents, risk to the public from fuel-handling accidents may exceed the risk from SNF storage and processing accidents.

If the Idaho National Engineering Laboratory were not selected as a regional site under Regionalization 4B, the consequences and risks of accidents associated with SNF storage would be the same as described under the No Action alternative (Section 5.15 of Appendix B). The consequences of fuel-handling accidents would be the same as described under the No Action alternative, but increased transporting and handling of SNF would result in a frequency of fuel-handling accidents about nine times higher than for the No Action alternative (Slaughterbeck et al. 1995). Because of the increased frequency of fuel-handling accidents, risk to the public from fuel-handling accidents may exceed the risk from SNF storage accidents.

Savannah River Site. Accident risks under Regionalization 4A would be essentially the same as those for the 1992/1993 Planning Basis alternative. The accident frequency for the highest risk accident, a fuel assembly breach, would be expected to be about 0.44 fuel assembly breaches per year of operation with implementation of this alternative. The estimated risk of latent cancer fatalities to the general public, maximally exposed offsite individual, and co-located worker would be 3.7 10-3, 4.4 10-7, and 2.1 10-6 per year of operation, respectively.

The implementation of Regionalization 4B at the Savannah River Site, including the three options of dry storage, wet storage, and processing followed by dry storage, would not result in accidents significantly different from those identified for the same options under the Decentralization alternative (Section 5.15 and Attachment A of Appendix C). Because of an increase in the amount of SNF handled, however, the accident frequency for some accidents would increase.

Under Regionalization 4B, the accident frequency for the highest risk accident, a fuel assembly breach, would be expected to be about 0.41 fuel assembly breaches per year of operation with implementation of this alternative. This results in a proportional increase in risk to the general public and the workers. The estimated risk of latent cancer fatalities to the general public, maximally exposed offsite individual, and co-located worker would be 3.5 10-3, 4.1 10-7, and 2.0 10-6 per year of operation, respectively. With regionalization elsewhere, the highest risk accident would still be the fuel assembly breach with an estimated risk approximately the same as with the No Action alternative.

Naval Facilities. The accident risks associated with the implementation of the Regionalization alternative at sites other than the Idaho National Engineering Laboratory are presented in detail in Attachment F of Appendix D. That evaluation considered the accidents associated with operation of an expended core facility and wet and dry storage facilities at the Hanford Site, Savannah River Site, Oak Ridge Reservation, and Nevada Test Site. Accidents evaluated were the same set of accidents identified for the Decentralization alternative. The maximum risk accidents, for either the general population and workers at sites where an expended core facility might be located if they are associated with an expended core facility, are discussed under the affected sites.

Oak Ridge Reservation. The Oak Ridge Reservation would not be affected by Regionalization 4A. The implementation of Regionalization 4B at the Oak Ridge Reservation would be expected to be similar to implementation of the Centralization alternative, except that less storage requirements would be needed. Section 5.15 (Part 3) of Appendix F indicates that the accident consequences would be similar for both alternatives and that it is reasonable to assume that the accident consequences and risks described for the Centralization alternative would envelop the Regionalization alternative.

A wide range of accident scenarios were considered, including accidents initiated by operational events, external hazards such as aircraft crashes, and natural phenomena such as earthquakes. The highest risk SNF-related accidents identified were (a) a fuel assembly breach as a result of dropping the assembly, objects falling on the assembly, or cutting into the fuel portion of the assembly, (b) a dropped fuel cask, (c) a severe impact that results in breach of a transport cask and fire, (d) an aircraft crash into the SNF dry storage facility, (e) an aircraft crash into the SNF dry cell facility, (f) a wind-driven missile impact into storage casks, and (g) and aircraft crash into a water storage pool.

The highest risk to the general population would be a fuel assembly breach, with an estimated frequency of 0.16 per year. General population consequences were estimated to be approximately 2.1 10-2 latent cancer fatalities per year. The estimated risk to the general population, taking into account the probability of occurrence of this accident, would be 3.4 10-3 latent cancer fatalities per year. The estimated probability of maximum latent cancer fatalities to the maximally exposed individual would be 6.0 10-6.

The dropped fuel cask accident has the maximum risk to workers with an estimated frequency of less than 1 in 10,000 per year. A worker downwind of the accident was estimated to receive a dose that corresponds to an estimated probability of 1.9 10-3 latent cancer fatalities. The estimated risk for a worker would be 1.9 10-7 latent cancer fatalities per year.

Workers in the immediate vicinity of the cask drop accident could receive very high doses; however, the doses would not result in a fatality. For that accident, workers could be expected to be very near the cask when it drops and receive both direct radiation as well as inhale airborne fission products. Workers would be expected to quickly evacuate the area and thus reduce their potential radiation exposure.

Nevada Test Site. The implementation of Regionalization 4B at the Nevada Test Site would also be expected to be similar to implementation of the Centralization alternative, except that storage requirements would be less. Section 5.15 (Part 2) of Appendix F indicates that the accident consequences would be similar for both alternatives and that it is reasonable to assume that the accident consequences and risks described for the Centralization alternative would envelop the Regionalization alternative.

A wide range of accident scenarios were considered for the Centralization alternative, which also apply to Regionalization 4B, including accidents initiated by operational events, external hazards such as aircraft crashes, and natural phenomena such as earthquakes. The highest risk SNF-related accidents identified for the Nevada Test Site were a fuel assembly breach (highest risk to the general public) and a dropped fuel cask (highest risk to workers).

The fuel assembly breach is the highest risk to the general population with an estimated frequency of 0.16 per year and an estimated offsite population dose corresponding to 6.6 10-4 latent cancer fatalities. The estimated risk to the general population, taking into account the probability of occurrence of this accident, would be 1.1 10-4 latent cancer fatalities per year. The potential dose to the maximally exposed offsite individual would correspond to a probability of a latent cancer fatality of 1.6 10-7.

The dropped fuel cask accident was the highest risk accident to workers with an estimated frequency of less than 1 in 10,000 per year. A worker approximately 100 meters (330 feet) downwind of the accident would have a probability of a latent cancer fatality of 1.9 10-3. The estimated risk to a worker would be 1.9 10-7 latent cancer fatalities per year of operation.

Workers in the immediate vicinity of the cask drop accident could receive very high doses; however, the doses would not result in a fatality. For that accident, workers could be expected to be very near the cask when it drops and receive both direct neutron and gamma radiation as well as inhale airborne fission products. Workers would be expected to quickly evacuate the area and thus reduce their potential radiation exposure.

Other Generator/Storage Locations. For Regionalization 4A and 4B, the accident risks would be expected to be similar to the accident risks under the No Action alternative.

5.1.5.5 Nonradiological Accidents.

The maximum reasonably foreseeable chemical accident at the Idaho Engineering National Laboratory, Savannah River Site, and other generator/storage locations would be similar to those described under the No Action alternative. An accident during the operation of a wet storage facility at the Hanford Site could release sulfuric acid and subject workers to fatalities or serious health effects.

Two independent accidents have been evaluated to describe the maximum reasonably foreseeable chemical accident during the operation of the expended core facility at each of its potential locations. Such a release could subject workers to chemical concentrations that could cause fatalities or serious health effects but would not subject the public to such concentrations except at potential locations on the Oak Ridge Reservation and adjacent to the Savannah River Site.

5.1.5.6 Transportation.

Regionalization 4A (by fuel type)-

Shipments. Under Regionalization 4A, the same SNF types would be transported as under the 1992/1993 Planning Basis alternative with differences occurring in the destinations of some SNF based on fuel type. Onsite shipments would relocate SNF for continued safe storage or stabilization.

Incident-Free Transportation. For Regionalization 4A, the incident-free transportation of SNF was estimated to result in total fatalities that ranged from 0.17 to 0.61 over the 40-year period 1995 through 2035. These fatalities represent the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

The reason for a range of fatalities was due to two factors: (a) the option of using truck or rail transport for DOE SNF (see Appendix I), and (b) different SNF management options at the Savannah River Site (see Appendix C). Navy shipments would be made using a combination of truck and rail; DOE shipments were assumed to be made using 100 percent truck or 100 percent rail.

The estimated number of radiation-related latent cancer fatalities for transportation workers ranged from 0.031 to 0.15, the estimated number of radiation-related latent cancer fatalities for the general population ranged from 0.054 to 0.41, and the estimated number of nonradiological fatalities from vehicular emissions ranged from 0.052 to 0.084.

Onsite shipments of SNF were estimated to result in 0.0025 to 0.0034 fatalities. Offsite shipments of SNF were estimated to result in 0.17 to 0.61 fatalities. These fatalities also represent the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

Transportation Accidents. The cumulative transportation accident risks over the 40-year operational period were estimated to be 0.0011 latent cancer fatality and 0.77 traffic fatality if all SNF were transported by truck. If all SNF were transported by rail, the corresponding risks were estimated to be 0.00037 latent cancer fatality and 0.76 traffic fatality.

As in the 1992/1993 Planning Basis alternative, the maximum reasonably foreseeable offsite transportation accident involves a rail shipment of special-case commercial SNF in a suburban population zone under neutral (average) weather conditions. The accident has a probability of occurrence of about 2.8 10-7 per year, and the consequences are the same as those described under the 1992/1993 Planning Basis alternative.

Onsite transportation of SNF would occur under Regionalization 4A at the Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site. The maximum reasonably foreseeable accident for this alternative would occur at the Idaho National Engineering Laboratory, and the potential impacts would be the same as those described under the No Action alternative.

Regionalization 4B (by geography)-

Shipments. Under Regionalization 4B, the same SNF types would be transported as under the 1992/1993 Planning Basis alternative with differences occurring in the destinations of the SNF based on geographical considerations. Non-naval SNF originating from western United States locations or points of entry would be transported to the Idaho National Engineering Laboratory, Hanford Site, or Nevada Test Site. Non-naval SNF originating from eastern United States locations or points of entry would be transported to the Savannah River Site or Oak Ridge Reservation. Naval SNF would not be split on an east-west basis because the Navy would operate a facility for examining naval SNF at one of the DOE sites. Onsite shipments at major DOE sites may relocate SNF from one facility or another for continued safe storage or stabilization, if applicable.

Incident-Free Transportation. For the six Regionalization 4B alternatives, the incident-free transportation of SNF was estimated to result in total fatalities that ranged from 0.14 (Idaho National Engineering Laboratory and Oak Ridge Reservation alternative) to 0.90 (Nevada Test Site and Oak Ridge Reservation alternative). The other four alternatives would result in fatalities between these two alternatives. These fatalities were over the 40-year period 1995 through 2035 and represent the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

The reason for a range of fatalities was due to two factors: (1) the option of using truck or rail transport for DOE SNF (see Appendix I), and (2) the six regionalization alternatives. Navy shipments would be made using a combination of truck or rail; DOE shipments were assumed to be made using 100 percent truck or 100 percent rail.

For regionalization at the Idaho National Engineering Laboratory and Oak Ridge Reservation, the estimated number of radiation-related latent cancer fatalities for transportation workers was 0.033, the estimated number of radiation-related latent cancer fatalities for the general population was 0.043, and the estimated number of nonradiological fatalities from vehicular emissions was 0.059.

For regionalization at the Nevada Test Site and Oak Ridge Reservation, the estimated number of radiation-related latent cancer fatalities for transportation workers was 0.21, the estimated number of radiation-related latent cancer fatalities for the general population was 0.60, and the estimated number of nonradiological fatalities from vehicular emissions was 0.091.

For regionalization at the Idaho National Engineering Laboratory and Oak Ridge Reservation, onsite shipments of SNF were estimated to result in 0.0025 fatalities. Offsite shipments of SNF were estimated to result in 0.13 fatalities. These fatalities also represent the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

For regionalization at the Nevada Test Site and Oak Ridge Reservation, onsite SNF shipments were estimated to result in 0.0023 fatalities. Offsite shipments of SNF were estimated to result in 0.90 fatalities. These fatalities also represent the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

Transportation Accidents. Cumulative accident risks for transportation by truck would range from 0.00090 latent cancer fatalities and 0.72 traffic fatalities for regionalization at the Idaho National Engineering Laboratory and Savannah River Site, to 0.0012 latent cancer fatalities and 1.0 traffic fatalities for regionalization at the Nevada Test Site and Oak Ridge Reservation. Cumulative accident risks for transportation by rail would range from 0.00024 latent cancer fatalities and 0.72 traffic fatalities for regionalization at the Idaho National Engineering Laboratory and Oak Ridge Reservation, to 0.00035 latent cancer fatalities and 0.91 traffic fatalities for regionalization at the Nevada Test Site and Oak Ridge Reservation.

As in the 1992/1993 Planning Basis alternative, the maximum reasonably foreseeable offsite transportation accident would involve a rail shipment of special-case commercial SNF in a suburban population zone under neutral (average) weather conditions. The accident has a probability of occurrence that ranges from about 2.7 10-7 per year for regionalization at the Hanford Site and Savannah River Site, to about 3.7 10-7 per year for regionalization at the Nevada Test Site and Savannah River Site. Accident consequences would be the same for each alternative and would be the same as those described under the 1992/1993 Planning Basis alternative.

Onsite transportation of SNF would occur under Regionalization 4B at the Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site. The maximum reasonably foreseeable accident for this alternative would occur at the Idaho National Engineering Laboratory, and the potential impacts would be the same as those described under the No Action alternative.

5.1.6 Centralization Alternative

Under this alternative, all stored and newly generated SNF would be transported to and stored at one of five sites: the Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, Oak Ridge Reservation, or Nevada Test Site. SNF management activities at unselected sites would cease. All SNF-related research and development activities would be conducted at the selected site, and the expended core facility would also be located there.

The implications of this alternative would be similar to those of Regionalization 4B alternative for western sites, but if an eastern site were selected, considerably greater volumes of SNF would be stored there than under any other alternative because the site would receive fuels from the Hanford Site and the Idaho National Engineering Laboratory. Therefore, substantially larger storage facilities would be needed under this alternative than under any other. New facilities with the largest capacity for SNF would be built at the

Oak Ridge Reservation and Nevada Test Site because they do not now have the capacity to accept additional fuels and do not currently store significant volumes of SNF. The potential environmental consequences at these sites are described below.

5.1.6.1 Socioeconomics.

The Centralization alternative would result in the largest socioeconomic impact in terms of the number of direct jobs created (or lost) on a local basis by SNF management activities (see Figure 5-7). The change in site employment would range from a decrease of less than 3 percent of total site employment at the Idaho National Engineering Laboratory to a maximum increase of about 13 percent above existing site employment at the Nevada Test Site when an expended core facility were constructed at the site. The intensity of this impact at the major DOE sites would depend on (a) whether the SNF management programs used existing personnel or required workers to move into the region, and (b) future actions at each site competing for the available labor pool. Under Centralization if the site were selected, the peak in employment would occur at the Savannah River Site where an additional 1,700 workers would be required for the proposed SNF management activities, an increase of approximately 11 percent above the projected 1995 baseline. If the site were not selected, the peak in employment would be an additional 580 workers at the Hanford Site or approximately 3 percent above the projected 1995 baseline. If either the Hanford Site, Idaho National Engineering Laboratory, or Savannah River Site were not selected as a central site under the Centralization alternative, there would ultimately be a reduction in employment equal to existing employment for SNF management at these sites. This would add to the forecast loss of jobs at each of these sites. In the short term, additional jobs would be required to prepare SNF for transport offsite (see Figure 5-5). The closure of the Expended Core Facility at the Idaho National Engineering Laboratory, however, would lead to a long-term loss of jobs as well, increasing the rate of job loss at that site.

Sites selected as central sites would generally have increased employment over baseline levels (see Figure 5-6). This increased direct employment would also result in an indirect increase in employment in the surrounding communities. At the Oak Ridge Reservation, the associated population growth could result in increases in capital expenditures to meet the increased demand of housing, utilities, including electricity generation, wastewater treatment, and water, transportation, and education facilities. At the Hanford Site, centralization activities could strain the housing market and add to school-capacity concerns. For centralization at the Savannah River Site or the Idaho National Engineering Laboratory, DOE expects that potential impacts on the demand for community resources and services would be minimal. For centralization at the Nevada Test Site, there is a potential increase in housing demand. Overall socioeconomic impacts for centralization at the Nevada Test Site could be absorbed within the projected expansion of the local economy, infrastructure, public service, and real estate development.

5.1.6.2 Utilities (Electricity).

The effect on power consumption from implementing the Centralization alternative would be generally similar to that described for Regionalization 4B where the SNF is transported offsite or where the SNF is transported to the regional site except at the Savannah River Site.
Power consumption minimum increase would be about 8 percent over the site baseline usage at the Savannah River Site from the construction and operation of additional wet storage facilities under the

Centralization alternative. Figures 5-8 and 5-9 illustrate the Centralization impacts for the two cases: if a site were selected or not selected as the central site (compare with Figures 5-5 and 5-7). The impacts would be the same as those described in Section 5.1. Thus, for example, electric power requirements with centralization at the Nevada Test Site would be similar to Regionalization 4B at the Nevada Test Site with a replacement expended core facility also located at that site (Figure 5-6).

Under the Centralization alternative at Hanford, the power consumption would rise by approximately 3 percent if SNF were only stored and could rise as much as 40 percent if processing were required. While the increase in power required for processing appears large (as a percent of baseline) when compared to the Savannah River Site, much of the difference would be the result of a higher Savannah River Site baseline with power consumption.

5.1.6.3 Materials and Waste Management.

The Centralization alternative would have similar effects at the major DOE sites to those described in Section 5.1.5.3 for the Regionalization alternative (see Figures 5-5 and 5-7). If a site were not selected as the central site, the annual volume of waste generated from SNF management activities would ultimately decrease; however, transient activities to stabilize and package the fuel could be substantial. The site selected as the central site would increase the annual volume of wastes generated from SNF management activities. The increase in waste would not necessarily be proportional to the larger amount of SNF being managed onsite because the originating sites would characterize and can their fuel before transport so it could be placed directly into storage at the receiving site. The waste volumes would be generated from transferring fuel from water pools at some sites, characterizing and canning small amounts of new fuel, and operating the expended core facility. Figures 5-8 and 5-9 show the effects of not being selected as well as being selected as the central site for SNF management activities.

Figure 5-8. Summary of impacts for the Centralization option if sites were not selected as a central site. (The maximum incremental change from baseline is illustrated in graphs. Input data are summarized in Appendix K.)

Figure 5-9. Summary of impacts for the Centralization option if sites were selected as a central site and have an expended core facility. (The maximum incremental change from baseline is illustrated in graphs. Input data are summarized in Appendix K.)

5.1.6.4 Radiological Impacts.

For the Centralization alternative, the radiological impacts from both normal operations and accidents at both the originating site and the central storage site would be expected to be low and similar in magnitude. Accident analysis for both existing and proposed SNF interim storage facilities indicates that the probabilities of accidents with the potential for significant impacts would be extremely low.

Figure 5-7 illustrates the estimated latent cancer fatalities among the population within 80 kilometers (50 miles) from SNF operations at each of the major sites. For each major site, this figure includes the potential impacts associated with site SNF operations with centralization at another site, as well as with centralization at that site.

Accident risks from SNF activities would be principally because of handling and storage activities and, therefore, would be expected to be similar for each of the centralization sites. The principal differences would be due to activities at the existing SNF sites necessary to prepare the SNF for transport to the central site.

SNF Facility Accidents-

Hanford Site. The implementation of the Centralization alternative at the Hanford site would be expected to result in accident risks for some accidents slightly different from those identified for the Decentralization alternative (Section 5.15 of Appendix A). The amount of SNF handled at the dry storage facility would be greater, resulting in an increase in the accident probability for the dry storage cask impact and fire to approximately 8 in 1,000,000. The estimate of risk from this, the highest risk accident to the general population, would be 6.5 10-4 latent cancer fatalities in the general population per year of operation. The corresponding risk to an individual worker would be 7.5 10-7 potential latent cancer fatalities per year of operation.

Implementation of the Centralization alternative (or Regionalization 4B) elsewhere reduces the estimates of accident risks from those identified for the Decentralization alternative because the existing storage facilities would be shut down and the amount of SNF handled at the site decreases slightly. The accident probability for the dry storage cask impact and fire would be expected to decrease slightly, to approximately 5 in 1,000,000. This yields an estimated accident risk to the general population of 4.1 10-4 latent cancer fatalities per year of operation. The corresponding highest risk accident to a worker would be 4.75 10-7 potential latent cancer fatalities per year of operation.

Idaho National Engineering Laboratory. The implementation of the Centralization alternative at the Idaho National Engineering Laboratory is estimated in Section 5.15 of Appendix B to result in additional accident scenarios and accident risks from those identified for the No Action alternative due to the assumed resumption of chemical processing of SNF at the Idaho Chemical Processing Plant. The consequences and risks from SNF-related accidents would be the same as Regionalization 4B if the Idaho National Engineering Laboratory is selected as a regional site.

The implementation of the Centralization alternative at a site other than the Idaho National Engineering Laboratory would result in potential accident consequences and risks the same as the Regionalization 4B when the Idaho National Engineering Laboratory is not selected as a regional site.

Savannah River Site. The implementation of the Centralization alternative at the Savannah River Site, including the three options of dry storage, wet storage, and processing followed by dry storage, is assessed in Section 5.15 and Attachment A of Appendix C to result in accidents not significantly different from those identified for the same options under the Decentralization alternative. Because of an increase in the amount of SNF handled, however, the accident frequency for some accidents would increase.

The accident frequency for the highest risk accident, a fuel assembly breach, would be expected to be about 0.84 fuel assembly breaches per year of operation with implementation of this alternative. The estimated risk of latent cancer fatalities to the general public, maximally exposed offsite individual, and co-located worker would be 7.2 10-3, 8.4 10-7, and 4 10-6 per year of operation, respectively. With centralization elsewhere, the highest risk accident would still be the fuel assembly breach with an estimated risk approximately the same as with the No Action alternative.

Oak Ridge Reservation. The accident risks associated with implementation of the Centralization alternative at the Oak Ridge Reservation are presented in detail in Section 5.15 (Part 3) of Appendix F. These accident risks are summarized under Regionalization 4B.

Nevada Test Site. The accident risks associated with implementation of the Centralization alternative at the Nevada Test Site are presented in detail in Section 5.15 (Part 2) of Appendix F. These accident risks are summarized under Regionalization 4B.

Other Generator/Storage Locations. The accident risks under the Centralization alternative would be expected to be the same as the accident risks under the No Action alternative.

5.1.6.5 Nonradiological Accidents.

Abnormal operational events could result in the release of toxic or hazardous substances from the centralized facility or from SNF management facilities at the other storage/generator sites prior to the shipment of SNF to the central site. The events that would be expected to exceed exposure guidelines would be similar to those described under the 1992/1993 Planning Basis alternative.

Two independent accidents have been evaluated to describe the maximum reasonably foreseeable chemical hazard during the operation of the expended core facility at each of its potential locations. Such a release could subject workers to chemical concentrations that would exceed the Emergency Response Planning Guideline value but would not subject the public to such concentrations except at potential locations on the Oak Ridge Reservation and adjacent to the Savannah River Site.

5.1.6.6 Transportation.

Shipments-Under the Centralization alternative, all stored and newly generated SNF would be transported to one of five sites: the Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, Oak Ridge Reservation, or Nevada Test Site.

Incident-Free Transportation-For the five Centralization alternative sites, the incident-free transportation of SNF was estimated to result in total fatalities that ranged from 0.21 (centralization at the Oak Ridge Reservation) to 1.7 (centralization at the Savannah River Site). These fatalities were over the 40-year period 1995 through 2035 and represent the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

The range of fatalities was due to two factors: (a) the option of using truck or rail transport for DOE SNF (see Appendix I) and (b) the five centralization options. Navy shipments would be made using a combination of truck and rail; DOE shipments were assumed to be made using 100 percent truck or 100 percent rail.

For centralization at the Oak Ridge Reservation, the estimated number of radiation-related latent cancer fatalities for transportation workers was 0.050, the estimated number of radiation-related latent cancer fatalities for the general population was 0.073, and the estimated number of nonradiological cancer fatalities from vehicular emissions was 0.083.

For centralization at the Savannah River Site the estimated number of radiation-related latent cancer fatalities for transportation workers was 0.43, the estimated number of radiation-related latent cancer fatalities for the general population was 1.2, and the estimated number of nonradiological fatalities from vehicular emissions was 0.11.

For centralization at the Oak Ridge Reservation, onsite shipments of SNF were estimated to result in 0.0023 fatalities. Offsite shipments of SNF were estimated to result in 0.20 fatalities. These fatalities were also the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

For centralization at the Savannah River Site, onsite shipments of SNF were estimated to result in 0.0035 fatalities. Offsite shipments of SNF were estimated to result in 1.7 fatalities. These fatalities were also the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

Transportation Accidents-Cumulative accident risks for transportation by truck would range from 0.0048 latent cancer fatalities and 1.0 traffic fatalities for centralization at the Idaho National Engineering Laboratory, to 0.0020 latent cancer fatalities and 1.44 traffic fatalities for centralization at the Savannah River Site. Cumulative accident risks for transportation by rail would range from 0.0013 latent cancer fatalities and 0.95 traffic fatalities for centralization at the Idaho National Engineering Laboratory, to 0.0014 latent cancer fatalities and 1.19 traffic fatalities for centralization at the

Nevada Test Site.

For centralization at either the Hanford Site or Idaho National Engineering Laboratory, the maximum reasonably foreseeable offsite transportation accident would involve a rail shipment of special-case commercial SNF in a suburban population zone under neutral (average) weather conditions. The accident has a probability of occurrence of about 5 10-7 per year and the consequences would be the same as those described under the 1992/1993 Planning Basis alternative.

For centralization at the Oak Ridge Reservation or the Nevada Test Site, the maximum reasonably foreseeable offsite transportation accident involves a rail shipment of special case commercial SNF in an urban population zone under neutral (average) weather conditions. The accident has a probability of occurrence of about 1 10-7 per year and could result in an estimated 36 latent cancer fatalities in the exposed population for Oak Ridge Reservation; for the Nevada Test Site, the accident would result in approximately 36 latent cancer fatalities. For comparison, the same population would be expected to experience about 540,000 cancer fatalities from other causes. The probability of this accident occurring under stable (worst-case) weather conditions is less than 1 10-7 per year for urban and suburban zones; the probability of occurrence is 5.7 10-7 per year if the accident occurred in a rural population zone and could result in an estimated 2 latent cancer fatalities.

For centralization at the Savannah River Site, the bounding offsite transportation accident would involve a rail shipment of commercial SNF in a suburban population zone under stable (worst-case) weather conditions. The accident has a probability of occurrence of about 1.2 10-7 per year and could result in an estimated 55 latent cancer fatalities in the exposed population. For comparison, the same population would be expected to experience about 42,000 cancer fatalities from other causes. The probability of this accident occurring in an urban population zone is less than 1 10-7 per year. In a rural population zone, the accident consequences would be approximately 3 percent of the suburban zone consequences.

Onsite transportation of SNF would occur under the Centralization alternative at the Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site. The bounding accident among the three sites occurs at the Idaho National Engineering Laboratory, and the potential impacts would be the same as those described under the No Action alternative.

Table 5-2 summarizes the comparison of incident-free transportation fatalities for each of the SNF management alternatives. Table 5-3 provides the comparison of transportation accident risks for each of the SNF management alternatives.

Table 5-2. Comparison of incident-free transportation total fatalities for alternatives over the 40-year period.

	Minimum(a,b) total fatalities	Maximum(b,c) total fatalities
No Action	0.0089	0.0089
Decentralization	0.12 to 0.15	0.35 to 0.38
1992/1993 Planning Basis	0.14	0.45
Regionalization 4A (fuel type)	0.17	0.61
Regionalization 4B (geography)		
Idaho National Engineering Laboratory and Savannah Site	0.15 to 0.17	0.51 to 0.53
Idaho National Laboratory and Oak Ridge Reservation	0.14 to 0.15	0.53 to 0.54
Hanford Site and Savannah River Site	0.17	0.55 to 0.56
Hanford Site and Oak Ridge Reservation	0.15	0.57
Nevada Test Site and Savannah River Site	0.19	0.88
Nevada Test Site and Oak Ridge Reservation	0.17	0.90
Centralization		
Hanford Site	0.23	1.3
Idaho National Engineering Laboratory	0.21	1.1
Savannah River Site	0.26	1.7

Oak Ridge Reservation	0.21	1.6
Nevada Test Site	0.26	1.6

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a. The minimum total fatalities would be associated with transport of DOE fuel by rail; naval SNF shipments would be by both truck (onsite) and rail (offsite).

b. Total fatalities were calculated for the 40-year period 1995 through 2035 and were the sum of the estimated number of radiation-related latent cancer fatalities for workers and the general population and the estimated number of nonradiological fatalities from vehicle emissions.

c. The maximum total fatalities would be associated with transport of DOE fuel by truck, naval SNF shipments would be by both truck (onsite) and rail (offsite).

Table 5-3. Comparison of estimated transportation accident risks for alternatives over the 40-year period.

	Truck Accident Risks(a)		Rail Accident Risks(a)	
Alternative	Latent cancer fatalities	Traffic fatalities	Latent cancer fatalities	Traffic fatalities
No Action	4.1 X 10^-6	0.047	4.1 10-6	0.047
Decentralization(b)	0.00085 to 0.00090	0.20 to 1.01	0.00029 to 0.00034	0.26 to 1.07
1992/1993 Planning Basis	0.0010	0.70	0.00035	0.73
Regionalization 4A (fuel type)	0.0011	0.77	0.00037	0.76
Regionalization 4B (geography)				
Idaho National Engineering Laboratory and Savannah River Site	0.00090	0.72	0.00034	0.73
Idaho National Engineering Laboratory and Oak Ridge Reservation	0.00095	0.73	0.00024	0.72
Hanford Site and Savannah River Site	0.0013	0.84	0.00075	0.82
Hanford Site and Oak Ridge Reservation	0.0013	0.81	0.00050	0.78
Nevada Test Site and Savannah River Site	0.0012	0.99	0.00045	0.91
Nevada Test Site and Oak Ridge Reservation	0.0012	1.00	0.00035	0.91
Centralization				
Hanford Site	0.0050	1.10	0.0013	1.05
Idaho National Engineering Laboratory	0.0048	1.00	0.0013	0.95
Savannah River Site	0.0020	1.44	0.00080	1.09
Oak Ridge Reservation	0.0017	1.35	0.00055	1.00
Nevada Test Site	0.0050	1.33	0.0014	1.19

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a. Assumes SNF shipments would be 100 percent by truck or 100 percent by rail, except for naval SNF shipments that would be by both truck (onsite) and rail (offsite).

b. Range of values in each column for the Decentralization alternative reflects the different fuel examination options for naval SNF.

5.2 Issues Not Discussed In Detail

This section discusses potential impacts for issues that are not discussed in detail because they are small and do not distinguish among alternatives, but about which the public may have general interest. The discussion for each discipline generally concentrates on sites and alternatives that have the largest expected impacts, demonstrating that the environmental consequences for that discipline are not of sufficient importance to be given strong consideration in the programmatic decisionmaking process.

5.2.1 Land Use

The proposed alternatives would not result in major impacts on land use at either the DOE or the naval sites. The largest amount of land that would be disturbed at any of the DOE sites would be 53 hectares (130 acres) at the Hanford Site. This would occur under the Centralization alternative and would take less than 0.5 percent of the land at that site. Less than 6.5 hectares (16 acres) of land would be required at the naval sites for the No Action alternative for the storage of SNF on railcars, and no additional land outside of the existing sites would be required. At all SNF sites, new facilities would be located near existing facilities or new facilities would be built on previously disturbed or industrialized land. Additional land might be required for infrastructure and buffer zones if a new SNF management facility is required. Because less than 0.5 percent of the land at any of the DOE sites would be needed and the current land we at the naval sites would not change, land use was determined not to be a discriminating factor (discriminator) among sites or alternatives and is not considered further in this volume, Detail on land we impacts is presented in Appendices A through F. The EIS does not explicitly consider land that is currently used for SNF operations or land that might or might not be made available for other uses under some alternatives.

5.2.2 Cultural Resources

Cultural, archaeological, historic, and architectural resources are defined as prehistoric and historic sites, districts, structures, and evidence of human use that are considered important to a culture, subculture, or a community for scientific, traditional, religious, or other reasons.

Most of the major DOE sites and some of the naval sites contain areas of archaeological, cultural, or historical interest. Direct impacts to archaeological resources would be associated with ground disturbance activities. Indirect impacts would result from improved visitor access, changes in land status, or other actions that would limit future scientific investigation. Although the major DOE sites have not been surveyed completely, the locations for the construction of proposed new facilities have generally been evaluated for their cultural importance. No known cultural resources would be affected by construction under any of the proposed alternatives. Specific surveys would be conducted before beginning any construction to determine the impacts to cultural resources. As described in Section 5.7.3, if cultural resources (for example, prehistoric or historic artifacts) were encountered during construction, earth-moving activities would stop and the State Historic preservation officer would be contacted immediately. If Native American or Native Hawaiian resources were to be involved, their leaders would also be contacted. Impacts to cultural resources were determined not to be an important discriminator among sites and alternatives; therefore, they are not considered further in this chapter. Details on cultural impacts are given in Appendices A through F.

5.2.3 Aesthetic and Scenic Resources

At all DOE sites, any proposed new SNF management facilities would be located far from areas with public access. Where new facilities would be visible to the public, similar facilities are already visible. At naval sites, SNF storage locations would be located at existing industrial facilities. Aesthetic and scenic resources would not be significantly affected by SNF management activities and are not considered further in this chapter. Discussion of impacts on aesthetic and scenic resources are contained in Appendices A through F.

5.2.4 Geologic Resources

None of the sites has known significant geologic resources that would be affected by the alternatives. Except for the potential existence of gold, tungsten, and molybdenum at the Nevada Test Site, geologic resources at the candidate sites consist of surficial sand, gravel, or clay deposits that have low economic value. The alternatives that involve constructing new facilities would result in disturbing or extracting surface deposits to construct the facilities. New construction would increase the use of surface deposits (that is, sand and gravel deposits), but because of the large volume of these materials on the sites, the impact is expected to be small.

All the major DOE sites have experienced earthquakes; however, they are located in areas with low to moderate seismic potential with respect to more seismically active areas in the United States (Algermissen et al. 1982, 1990). Because any new facility would be constructed to meet current seismic design criteria for a given area, seismic concerns are not a discriminating factor among sites. Details on site geology are provided in Appendices A through F.

5.2.5 Air Quality

SNF management activities under some alternatives would result in slightly increased releases of pollutants to the atmosphere. At the major DOE sites, the projected emissions from SNF management activities would not contribute to nonattainment of state or Federal standards. There would be no impact on nonradiological ambient air quality at the naval sites (Appendix D). Construction activities at several different sites are expected to cause short-term, minor increases in fugitive dust emissions, but the use of standard dust suppression techniques would be expected to minimize this problem. These particulate emissions could temporarily affect visibility in localized areas but would not cause nonattainment of state or Federal standards. Because SNF management activities would not be expected to cause either radiological or nonradiological air quality impacts to exceed state or Federal standards at any site for any alternative considered, or to significantly affect air quality in any other respect, air quality impacts are not discussed further in this chapter. The potential radiological impacts on health are discussed in Section 5.1. The computer models used for evaluating air quality impacts, and detailed results are discussed in Appendices A through F.

5.2.6 Water Resources

The proposed alternatives would have small impacts on water resources at each of the candidate sites. Compared with existing activities at all proposed SNF sites, additional water consumption would be minor and would relate primarily to the increased demand of a larger work force because SNF water pools use recycled water. The maximum increase of water usage over baseline at any candidate site would be approximately 5 percent. There would be net increases in employment at the Oak Ridge Reservation, and the Nevada Test Site; however, water resources would not be expected to be appreciably affected under any alternative. Nevertheless, at the Nevada Test Site, where available water is limited, a cumulative water supply impact is possible. The effects of groundwater withdrawal from the Frenchman Flat hydrographic area at the Nevada Test Site to support a proposed SNF facility on groundwater yields are unknown and require additional study. The Frenchman Flat hydrographic area is part of the Ash Meadows sub-basin whose perennial yield has greatly exceeded its annual water withdrawals. Some potential also exists for minor, short-term impacts of sedimentation during construction at the Oak Ridge Reservation and the Savannah River Site.

Storing SNF in water pools creates a potential for radiological groundwater contamination through undetected leaks or accidents that breach containment systems. Releases to groundwater caused by accidental minor breaches of leak containment systems are very small compared with accidental minor releases, which are presented in Appendices A through F under Occupational and Public Health and Safety. Water resources are discussed in detail in Appendices A through F.

5.2.7 Ecological Resources

The major DOE sites under consideration are located on large reservations that are predominantly "natural." The naval sites, on the other hand, are generally much smaller with significant industrial infrastructure. Similarly, the majority of the other generator and storage sites are in urban or suburban settings, where natural flora and fauna are limited to species that have developed a tolerance to human activities. Therefore, the largest impacts to ecological resources are expected to occur at the five major DOE sites where undisturbed or semi-disturbed natural areas could be converted to industrial activity. Under any of the alternatives involving the construction of new facilities at DOE sites, individuals or small populations of some wildlife species may be disturbed, displaced, or destroyed.

The development of new DOE facilities would affect some natural habitats. The size of the areas affected would be small in relation to the size of the sites and the size of remaining natural habitats. The type of habitats affected would vary but would be typical of the regional area in which the sites are located. The habitat losses would probably not affect any threatened or endangered species or critical habitats with the possible exception of the proposed facilities at the Nevada Test Site and the Hanford Site. At the Nevada Test Site, the proposed SNF facilities could be constructed within the range of the desert tortoise, a federally listed threatened species. At the Hanford Site, construction related to SNF management could result in a habitat loss up to 28 hectares (70 acres) for Federal and state-listed candidate species (for example, loggerhead shrike, sage sparrows, burrowing owls, pygmy rabbits). As described in Section 5.7.7, mitigation plans would be developed in consultation with the appropriate agencies if any threatened or endangered species were identified on the project site. Habitat fragmentation is not expected because new facilities would be constructed adjacent to existing facilities. Because minor impacts to ecological resources would occur at all sites for all alternatives involving construction, ecology was not considered a significant discriminator among sites and, therefore, is not discussed further in this chapter. Appendices A through F present a detailed discussion of ecological impacts.

5.2.8 Noise

The construction of SNF management facilities at any of the sites would generate noise levels consistent with light industrial activity. However, at the major DOE sites, noise generated onsite does not propagate offsite at levels that would affect the general population. Noise at the naval sites is primarily from truck and car traffic, shiploading, and diesel-powered equipment. Noise impact analyses at the naval sites indicate that noise from construction or operation of facilities would not cause the ambient noise levels to exceed U.S. Environmental Protection Agency or state guidelines.
Construction would occur at the naval sites under the No Action and Decentralization alternatives.
Noise impacts would be expected to be comparable at the major DOE sites for all alternatives except for the No Action alternative, which does not involve construction of new facilities. Because these new facilities would be located in industrialized areas, however, no impacts are expected. Because noise impacts would be minor and do not differentiate among the sites or the alternatives, they are not considered further in this chapter. Details on the noise impact analyses are provided in

Appendices A through F.

5.2.9 Utilities and Energy

New facilities (or the restarting of idle facilities) would result in increased demands on water, power, and sewage. The greatest resource requirements would result from the implementation of the Centralization alternative. Based on available data, the increased water usage would range from less than 1 percent at the Idaho National Engineering Laboratory to a maximum of less than 5 percent above existing site usage at the Savannah River Site. Electricity requirements are discussed in Section 5.1. The increase in sewage generation resulting from implementation of the alternatives would range from less than 1 percent at the Idaho National Engineering Laboratory to a maximum of 9 percent at the Savannah River Site. A central sewage treatment system would have to be constructed for the SNF facilities at the Nevada Test Site under the Regionalization and Centralization alternatives if the Nevada Test Site were selected as a regional or central site. The existing system capacities at all sites could manage the estimated changes in utility usage rates for water. Appendices A through F provide details on utilities and energy consumption.

5.3 Cumulative Impacts

A cumulative impact on the environment results from the incremental impact of the action when added to other past, present, and reasonably foreseeable actions. "Other" actions include DOE projects at the potentially affected sites not related to SNF management, as well as projects proposed by other Government agencies, private businesses, or individuals. This type of an assessment is important because significant cumulative impacts can result from several smaller actions that by themselves do not have significant impacts. The programmatic cumulative impacts from the implementation of the DOE SNF Management Program are discussed in Section 5.3.1. The site-specific cumulative impacts are described in Section 5.3.2.

5.3.1 Programmatic Cumulative Impacts

On a nationwide basis, the implementation of any of the SNF Management Program alternatives would not be expected to significantly contribute to cumulative impacts. There would be a small change in regional employment, little use of nonrenewable resources, low radiological emissions, and a low rate of radioactive waste generation. Under most alternatives, subalternatives, and options, the activities required for SNF management would be very small in comparison to other non-SNF-related activities already underway at almost all sites where SNF would be stored. Even in those alternatives where there would be large changes in nonrenewable resource use at one or more sites (Regionalization by geography or Centralization), on a national scale, increases at the selected regional or central site would be compensated for by changes at nonselected sites, so the net change is very small.

Reasonably foreseeable projects that could contribute to cumulative impacts are identified for each of the DOE and naval sites in Appendices A, B, C, D, and F. For the major DOE sites, these projects are primarily associated with environmental restoration and waste management activities, one of the priorities being given to site management, and are being covered by the Waste Management Programmatic EIS and site-specific EISs. It is expected that SNF management activities would have consistently smaller impacts than the environmental restoration and waste management activities, and that the overall impact of SNF management would not contribute significantly to cumulative impacts on either a regional or a nationwide basis.

The transport of DOE and naval SNF over highways and railways is only one of the sources of radiological dose to the general public. The potential transport of commercial SNF for disposal in a repository, assumed to be in Nevada for purposes of analysis, the proposed transport of transuranic wastes to the Waste Isolation Pilot Plant in New Mexico, and the expected transport of radioisotopes used in medicine and other activities all would contribute to public exposures. Available historical data and projected future doses are summarized in Appendix I.

During analysis, the potential for significant cumulative impacts to other resources was considered; none were found. Cumulative impacts are described qualitatively because programmatic considerations do not require detailed information that depends on specific facility location or design. More detailed cumulative effects analysis will be performed for any actions that are proposed in the course of implementing programmatic SNF management decisions.

5.3.2 Site-Specific Cumulative Impacts

All of the sites contain facilities unrelated to SNF that may continue to operate throughout the duration of the SNF interim management program (approximately 40 years). Impacts from both construction and operation of SNF facilities would be cumulative with the impacts of existing and planned facilities or actions such as environmental restoration and waste management activities unrelated to SNF. Cumulative effects involving site-specific projects that are planned to occur simultaneously with SNF management activities at the major DOE sites are discussed in the site appendices. Not all planned facilities were factored into the assessment of cumulative impacts pending funding approval or resolution of DOE policy issues.

The following sections discuss cumulative impacts to those environmental resources identified in Appendices A through F. During analysis, the potential for significant cumulative impacts to other environmental resources (that is, geologic resources, aesthetic and scenic resources, and cultural resources) was evaluated; none were found.

5.3.2.1 Land Use.

Implementation of any of the SNF alternatives at the major DOE sites would have a minimal cumulative impact with respect to either the available land onsite or to the continued mission of the sites. The largest proportion of any site that would be required for all sitewide activities is less than 1 percent of the total site area.

5.3.2.2 Socioeconomics.

Depending on the economic status and outlook for an area, SNF activities coupled with other actions have the potential to strain or overburden the socioeconomic resources of certain areas, particularly if either the Regionalization or Centralization alternatives were selected with an expended core facility located at the site. For example, these cumulative effects could contribute to housing shortages, the need for additional schools, and increased demand for utilities and transportation.

Each site is anticipating an overall decline in site employment over the next few years; therefore, the existing work force could be reassigned to SNF management activities. However, it was assumed that the construction activities associated with the proposed SNF management alternatives would require the in-migration of construction workers. Although these construction activities are short-term with a duration of a few years, when addressed cumulatively with other reasonably foreseeable activities, there could be a socioeconomic impact in the communities surrounding the Hanford Site, Nevada Test Site, and Oak Ridge Reservation. For example, at the Hanford Site cumulative employment, housing requirements, and needs for schools would increase up to 1 percent over those based on present Hanford employment for SNF management activities only.

Impacts to socioeconomic resources associated with the implementation of proposed SNF actions at the Idaho National Engineering Laboratory, Savannah River Site, naval sites, and other generator sites are not expected to be sufficient to have a cumulative effect on the regional social infrastructure within each site's region of influence.

5.3.2.3 Air Quality.

The available data in Appendices A through F indicate that the cumulative air emissions from the Savannah River Site, Idaho National Engineering Laboratory, and naval sites, including those from the proposed SNF management alternatives, would not exceed the limits for nonradioactive air pollutants and would not threaten to exceed the limits for nonradioactive pollutants or the 40 CFR Part 61 limit of 0.01 rem (10 millirem) per year for radioactive emissions.

5.3.2.4 Water Resources.

Based on data available in Appendices A through F, the implementation of any of the SNF alternatives at the major DOE sites would result in minimal cumulative impacts to water resources under normal operations. The proposed SNF facilities and related management operations are designed to generate no liquid releases of wastewater to the subsurface or water resources containing radiological constituents or hazardous chemicals. The facilities would be constructed using state-of-the-art technologies, including secondary containment and leak detection and water balance monitoring equipment. Liquid effluent discharges from SNF activities will be monitored for the presence of radioactive and chemical constituents and determined suitable for land disposal as required under Federal and State regulations.

Water usage from SNF activities would also have a small cumulative effect on overall quantities of water available at the major DOE sites. The maximum increase over baseline water use would be approximately 5 percent for any of the proposed locations.

5.3.2.5 Biotic Resources.

Construction of the proposed SNF facilities in addition to other planned activities could disturb as much as 9 hectares (24 acres) of terrestrial habitat at the Hanford Site and as much as 13 hectares (31 acres) of previously disturbed land at the Idaho National Engineering Laboratory. No impacts to biotic resources would be expected at the Savannah River Site or Oak Ridge Reservation. However, construction activities at the Nevada Test Site and Hanford Site could result in habitat loss for either Federal and state candidate species or federally listed threatened species. For example, at the Hanford Site the Cumulative impact from planned activities including construction related to SNF management could result in habitat loss for Federal and state candidate species (for example, loggerhead shrike, sage sparrows, burrowing owls, pygmy rabbits). At the Nevada Test Site, the proposed SNF facilities would be constructed within the range of the desert tortoise, a federally listed threatened species. Therefore, the proposed SNF management activities in addition to other planned actions could result in a small cumulative loss of habitat for the desert tortoise.

5.3.2.6 Occupational and Public Heath.

The sources of radiation exposure to individuals consist of natural background radiation from cosmic, terrestrial, and internal body sources; medical radiation; and radiation from manmade sources, including consumer and industrial products, nuclear facilities, and weapons test fallout. At the Savannah River Site, for example, natural background radiation contributes about 82 percent of the dose received by an average member of the population within 80 kilometers (50 miles) of the site, medical exposure accounts for 15 percent of the annual dose, and the combined doses from weapons test fallout, consumer and industrial products, and air travel account for approximately 3 percent. DOE nuclear facilities at the Savannah River Site account for less than 0.1 percent of the total radiation exposure.

The radiological impacts from SNF management operations are exposures to both workers and the general public from normal operations and the risk of additional radiation exposures due to accidents. The major concerns with these exposures are whether the doses are sufficient to cause immediate harm and bow much they will increase the probabilities, among the exposed population, of latent cancer fatalities, nonfatal cancers, and genetic effects. Of further concern is that these SNF management-related exposures are in addition to those exposures and risks affecting the same workers and members of the general public from other sources. The cumulative impact of both the SNF-related increment and other possible sources is also a concern.

Cumulative Impacts to the General Public-The principal regulatory limit affecting emissions from DOE and naval sites is the Clean Air Act standard (40 CFR Part 61, Subpart H for DOE; Subpart I for the Navy) for airborne radionuclide emissions from DOE facilities.

This rule limits airborne emissions to those amounts that would not cause any member of the public to receive in any year an effective dose equivalent of more than 0.01 rem (10 millirem) per year. Implementation of any of the alternatives at any of the sites is not expected to result in normal releases exceeding this limit. The naval sites have demonstrated to the U.S. Environmental Protection Agency that, at 0.0001 rem (0.1 millirem) per year, they are at 1 percent of the limit and operation of SNF management facilities is not expected to change that conclusion. Data available for each of the sites (see Appendices A through F) indicate that over the 40-year planning period, the cumulative radioactive emissions from the existing, the potential SNF management activities, and reasonably foreseeable future site activities at any of the sites would not be expected to result in an additional latent cancer fatality among the general population surrounding the site, except for the Oak Ridge Reservation. With centralization at the Oak Ridge Reservation, operation of the proposed SNF management facilities over their expected 40-year lifetimes is estimated to result in a total population dose of approximately 2,500 person-rem. This equates to approximately two latent cancer fatalities over the period.

Cumulative Impacts on the Site Work Force - The cumulative impact of selection of either of the alternatives coupled with the existing and reasonably foreseeable actions has the potential to increase the radiological exposure to workers at the sites transporting and receiving the SNF. For both the transporting and receiving sites, the routine exposure to the workers is expected to increase because much of the dose to the workers is associated with SNF handling operations.

Because occupational worker exposures are easily monitored and controlled to levels a factor of 10 or more below the current standards, the overall average exposure per worker is expected to remain approximately constant at each of the SNF transporting and receiving sites with each of the alternatives. However, with options that involve more SNF activities, the number of SNF-related workers is expected to increase, thus increasing the collective radiation dose to the site work force.

As reported in Appendices A through F and summarized in Appendix K, the increases in collective dose to the work force varies from site to site and with the alternatives. At the Oak Ridge Reservation, for example, the increases due to SNF-related actions range to 3,200 person-rem over the 40-year planning period. The maximum SNF-related increase is equivalent to approximately one additional latent cancer fatality among the workforce.

5.3.2.7 Transportation.

Radiological Impacts - Table 5-4 summarizes the existing and reasonably foreseeable actions assessed to determine the cumulative impact for transportation for the SNF alternatives. The cumulative radiological impacts of incident-free transportation of SNF are presented in terms of radiation-related latent cancer fatalities. These results are summarized in Table 5-5 and more details are contained in Appendix I. Over the 93-year period from 1943 through 2035, the total number of radiation-related latent cancer fatalities was estimated to be 290, or approximately three latent cancer fatalities per year. General transport of radioactive material accounted for about 90 percent of these radiation-related latent cancer fatalities. The radiation-related latent cancer fatalities would be indistinguishable from other cancer fatalities and would be 0.001 percent of the total number of cancer fatalities that would be expected to occur. The radiation-related latent cancer fatalities associated with the alternatives evaluated in this EIS would be 5 x 10^-6 percent of the total number of cancer fatalities that would be expected to occur.

Traffic Accident Impacts - Fatalities involving the transport of radioactive materials for 1971 through 1993 were surveyed based on data in the Radioactive Material Incident Report database. This database contains information on radioactive materials transportation incidents

Table 5-4. Other activities included for assessment of cumulative impacts for transportation.

Activity	Description
Existing activities:	

Historical shipments	Historical shipments of SNF, Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, Oak Ridge Reservation, and Nevada Test Site
General transportation	Nationwide transport of radioactive materials for medical, industrial, fuel cycle, and disposal purposes
Reasonably foreseeable activities:	
Geologic repository	Shipments of commercial SNF and defense high-level waste to the geologic repository at Yucca Mountain, Nevada
Waste Isolation Pilot Plant	Shipments of transuranic waste to the Waste Isolation Pilot Plant at Carlsbad, New Mexico (including a 5-year Test Phase and 20-year Disposal Phase)
Submarine reactor compartments	Shipments of reactor compartments from Puget Sound Naval Shipyard to Hanford
Return of isotope capsules	Shipments of cesium-137 isotope capsules to the Hanford Site
Uranium billets	Shipment of low-enriched uranium billets from the Hanford Site to the United Kingdom

Table 5-5. Summary of transportation radiological cumulative impacts.

Category of shipment(a)	Occupational latent cancer fatalities	General population latent cancer fatalities
Projected SNF shipments for all alternatives		
Truck	0.00060 to 0.40	0.00017 to 1.2
Train	0.00060 to 0.060	0.00017 to 0.085
Historical SNF(b)	0.080	0.055
General transportation (1943 to 2035)(c)	120	140
Reasonably foreseeable actions(d)		
Truck	4.4	25
Train	0.33	0.85
Total cancer fatalities(c)	130	160

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a. See Table 54 and Appendix I for more details.
b. Shipments to Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, Oak Ridge Reservation, and Nevada Test Site. Includes transport of naval SNF to the Idaho National Engineering Laboratory.
c. Shipments are a combination of truck and train.
d. Shipments to the geologic repository, the Waste Isolation Pilot Plant, and shipments of submarine reactor compartments, isotope capsules, and uranium billets
e. Numbers may not sum due to rounding.

and accidents from the U.S. Department of Transportation, U.S. Nuclear Regulatory Commission, DOE, state radiation control offices, and media coverage. From 1971 through 1993, 21 traffic accidents involving 36 fatalities have occurred. These fatalities resulted from traffic accidents and were not associated with the radioactive nature of the cargo. No radiological fatalities because of transportation accidents have ever occurred in the United States. During the same time period, over 1,000,000 persons were killed in traffic accidents in the United States.

For the alternatives evaluated in this EIS, about one traffic accident fatality was estimated to occur. During the 40-year time period from 1995 through 2035 evaluated in this EIS, approximately 1,600,000 persons would be killed in traffic accidents in the United States.

5.3.2.8 Energy/Utilities.

Under certain SNF management alternatives, energy or utility requirements for SNF management in combination with other present for future projects, could stress or exceed the existing capacity at a site. The existing energy and capacity would be adequate for the SNF management alternatives at all sites with the possible exception of the Hanford Site and the Nevada Test Site.

If all SNF were transported to the Hanford Site under the Centralization alternative, then existing utilities, including water mains, power lines, sewage facilities, and telephone lines, would need to be extended to the project area. If the Centralization alternative was implemented in addition to other power-intensive activities (for example, operating a vitrification plant), existing capacity might be inadequate based on current consumption.

If the Centralization alternative were implemented at the Nevada Test Site, additional transmission lines might need to be constructed. In addition, a sewage treatment facility for the SNF management facility would have to be constructed at the Nevada Test Site if SNF management activities were implemented under the Regionalization and Centralization alternatives. Water supplies at the Nevada Test Site have been developed from local groundwater sources within the Ash Meadows Sub-basin. Existing withdrawals of groundwater from this sub-basin may have already exceeded its localized perennial yield (Appendix F). SNF management facilities at this site may result in the need for additional water.

5.3.2.9 Waste Generation.

Waste volumes generated from SNF management activities depend on the alternative chosen. In general, the Regionalization and Centralization alternatives at the Idaho National Engineering Laboratory, and the alternatives at the Savannah River Site involving processing, would result in the largest cumulative impact on waste generation. Under some options, the total increase in waste generation could be four times the current facility baseline and require the construction of additional facilities.

To evaluate the adequacy of existing storage capacity, waste volumes generated from the SNF management alternatives were compared with current generation rates at the major DOE sites. At the Navy sites, the rate of low-level waste generation would be small and not stress existing capacity. No mixed, transuranic, or high-level waste would be generated from SNF activities at the Navy sites (Appendix D).

At the major DOE sites, increased low-level waste generated from SNF management activities would range from about 1 percent above baseline generation rates at the Oak Ridge Reservation to approximately four times above baseline at the Savannah River Site for centralization and processing options, respectively. Adequate storage capacity exists at all sites except at the Idaho National Engineering Laboratory, where beyond the year 2005 low-level waste storage capacity may be strained (Appendix B).

The increased volume of transuranic waste that could be generated from SNF management activities could exceed 100 percent above baseline at the Idaho National Engineering Laboratory, Savannah River Site, Oak Ridge Reservation, and Nevada Test Site based on centralization and processing options. This percentage is high at both Nevada Test Site and the Oak Ridge Reservation because neither of these sites is currently generating transuranic waste and because both sites have projected that future transuranic waste volumes will only be produced by SNF management activities. However, adequate storage capacity exists at both sites.

The volume of high-level waste generated from SNF management activities has been estimated to range from approximately 21 percent to greater than 100 percent above current site baseline generation rates at the Idaho National Engineering Laboratory and the Savannah River Site, respectively. Again, the percentage is high at the Savannah River Site because essentially no high-level waste is currently being generated onsite, but with processing approximately 2 cubic meters per year of high-level waste could be generated. Adequate storage capacity exists at the sites. No high-level waste would be generated at either the Nevada Test Site or the Oak Ridge Reservation.

5.4 Adverse Effects That Cannot Be Avoided

Adverse impacts would result, no matter the alternative, from radiation exposure associated with maintaining facilities that are at or near the end of their design life, until completion of the construction of new facilities. However, these exposures would be kept within applicable regulatory requirements and other applicable guidelines and would be controlled to levels that are as low as reasonably achievable. Implementation of any alternative except the No Action alternative would increase the volume of radioactive waste, in particular, low-level waste generated at the major DOE sites. Under the action-based alternatives, where SNF is transported to other sites, there would be a small increased potential for exposure to the general population when the SNF is in transit.

Under the No Action alternative, there would be several adverse effects that could not be avoided. These include the continuation of the environmentally degraded state of the three major DOE sites because existing facilities would deteriorate further. Naval and research reactor SNF would be stored near population centers, potentially increasing the consequences of an SNF handling or management accident. This alternative also presents a greater personnel requirement for managing SNF interim storage facilities. (Under other alternatives, the apparently higher personnel requirement would be for additional management activities that would not be done under the No Action alternative - they are not just related to storage facilities.) In addition, the shutdown of research reactors that could not store SNF onsite would result in the loss of several hundred reactor operator and research positions.

Under Regionalization 4B and Centralization alternatives, one or more major DOE sites would transport all its SNF to another major DOE site, the facilities at the transport sites would be shut down, and facilities at the receiving site(s) would be built. This would cause the relocation of many jobs associated with SNF management and duplicate some existing facilities. While new facilities are generally required at each DOE site under many alternatives, there are existing facilities that can be used for storage at major sites that would be shut down prior to the end of their useful design life.

The construction and operation of any of the facilities under consideration for storage of SNF would result in some adverse impacts to the environment. Although location-dependent, changes in project design and other measures (for example, sound engineering practices during construction) would eliminate, avoid, or minimize these impacts. In general, most of the adverse impacts would be of short duration and would result from the construction of proposed facilities. For example, noise, atmospheric emissions, fugitive dust, sediment runoff, and solid waste would be expected to increase during construction. Section 5.7 discusses potential mitigation measures that could be used to control or minimize impacts to the environment. See Appendices A through F for site-specific discussion on adverse effects that cannot be avoided.

5.5 Relationship Between Short-Term Use of the Environment

and the Maintenance and Enhancement of Long-Term Productivity

The implementation of any of the SNF management alternatives would cause some adverse impacts to the environment and permanently commit certain resources. This section describes the relationship between short-term influences from the implementation of an SNF management alternative and the associated long-term effects.

The proposed alternatives for SNF management would require the short-term use of multiple resources; for example, energy, materials of construction, and labor to achieve the objective of safely securing SNF to minimize the risk to workers, to the public, and to the environment. For example, if no action were taken, degradation of the fuel and SNF facilities would occur with the potential for releases to the environment. Releases to the environment could contaminate land near the point of storage, thereby reducing the potential future use. By consolidating and containing the SNF at specific locations, the potential for impacting the environment would be reduced at the other locations. After the implementation of a comprehensive SNF management strategy, those areas currently used for SNF management could be released to allow other productive use, such as for research or technology development.

The premature shutdown of research reactors due to a lack of sufficient SNF interim storage space under the No Action alternative could have an impact upon the national and regional communities in which they are located. Most of these reactors are the only regional source of radiopharmaceuticals and often they are important centers of medical and biological research. The sites where these reactors are located, many of them universities, are unique training facilities for students in many fields of research and development: materials science, environmental science, physics, biology, and electronics.

In the medical arena, research reactors have proven to be vital to cancer therapy, diagnostic imaging, studies of the biological effects of radiation, and other important medical applications.

Demand for medically important radioisotopes would not decrease merely because the source was shut off. The continued demand for radioisotopes would be met by placing orders with remaining reactors, which may be farther away from the place where they are needed. Many medically important isotopes (for example, iodine-131) have such short half-lives that the amount transported must include enough to allow for radioactive decay during shipment. Therefore, shutdown of reactors would result in the need to produce and transport larger quantities of radiopharmaceuticals.

Shutdown of research reactors could produce an impact on commercial enterprises that are engaged in the doping of silicon crystals through neutron irradiation. The doped silicon chips are widely used in electronic components such as the computers used in automobile engines.

Graduates trained at these facilities contribute to a wide variety of nuclear industries and to Government agencies involved with (a) monitoring nuclear technology, for example, regulatory agencies, Federal and international inspections, (b)hardware for inspections, and (c) remote monitoring.

Development of new SNF interim management facilities would commit lands to those uses from the time of construction through cessation of operations. At that time, these facilities could be converted to other uses or decontaminated, decommissioned, and the site restored to its original land use. Existing SNF management facilities could also be converted to other uses or the lands restored following their decommissioning.

See Appendices A through F for site-specific discussions on the relationship between short-term use of the environment and the maintenance and enhancement of long-term productivity.

5.6 Irreversible and Irretrievable Commitment of Resources

The irreversible and irretrievable commitment of resources resulting from the construction and operation of SNF management facilities would involve materials that could not be recovered or recycled, or resources that would be consumed or reduced to unrecoverable forms. For example, the construction and operation of an SNF facility at any of the locations under consideration would consume irretrievable amounts of electrical energy, fuel, construction materials, and miscellaneous chemicals. Some construction materials are recyclable and, therefore, should not be considered irreversible and irretrievable commitments of resources. Furthermore, some of the resources would be irretrievable because of the nature of the commitment or the cost of reclamation. For example, human resources used for the construction and operation of the proposed SNF facilities would be irretrievably lost since these resources would be unavailable for use in other work activity areas. On the whole, however, SNF management is not particularly resource intensive. See Appendices A through F for site-specific discussions on irreversible and irretrievable commitments of resources.

5.7 Potential Mitigation Measures

This section summarizes measures that D0E(a) could implement to avoid or reduce impacts to the environment. Possible mitigation measures are generally the same for all alternatives and are summarized by resource category below. Although the environmental effects described in Sections 5.1 through 5.3 may not require mitigation, the range of potential mitigation actions is described below. For all sites, impacts to land use and aesthetic and scenic resources would be small; therefore, mitigation measures for these attributes would not be required.

5.7.1 Pollution Prevention

Implementation of the SNF management alternatives would generate waste with the potential for releases to air and water. To control both the volume and toxicity of waste generated and to reduce impacts on the environment, pollution prevention practices would be implemented.

DOE is responding to Executive Order 12856, Federal Compliance with Right to Know Laws and Pollution Prevention Requirements, and associated DOE orders and guidelines by reducing the use of toxic chemicals; improving emergency planning, response, and accident notification; and encouraging the development and use of clean technologies and the testing of innovative pollution prevention technologies. Pollution prevention programs have been implemented at each site. Program components include waste minimization, source reduction and recycling, and procurement practices that preferentially procure products made from recycled materials. Portions of the pollution prevention program have been implemented at the existing DOE and naval sites for nearly 10 years. For example, the waste minimization program at the Savannah River Site has decreased the amount of all waste types generated by material substitutions.

Implementation of the pollution prevention plans minimizes the amount of waste generated during SNF management activities.

5.7.2 Socioeconomics

The SNF management alternatives would require additional workers for construction, stabilization, monitoring, and maintenance of SNF. This would produce a socioeconomic effect depending on the available site work force, regional labor pool, and community infrastructure. Minor socioeconomic impacts would be expected from implementation of the SNF management alternatives; the mitigation measures described below could be used to further minimize the effect on the community.

Construction and operation-related impacts resulting from increased labor and capital requirements could be reduced by coordinating with local communities and county planning agencies. Effective planning would address changes in community services, housing, infrastructure, utilities, and transportation. DOE would coordinate, in an appropriate manner, with the local and regional planning agencies to address impacts on the work force and community infrastructure. This could be facilitated through the development of citizen advisory boards. The timing of certain activities that have been proposed to proceed concurrently could also be adjusted to minimize socioeconomic impacts.

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a. Because this is an EIS issued by the DOE, it contains language concerning compliance with applicable environmental requirements, taking appropriate mitigative measures to reduce environmental impacts, and other matters phrased in the context of DOE as the party taking the actions. As a cooperative agency, and because Navy sites are also evaluated in this EIS, the Navy will also assure compliance with applicable environmental requirements and take other appropriate measures for its facilities in a consistent and appropriate fashion.

5.7.3 Cultural Resources

Impacts to cultural resources could occur during construction and earth-moving activities associated with the SNF management alternatives. Areas of proposed ground disturbance would be assessed for the potential to contain important archaeological and paleontological resources. Each DOE operations office is responsible for establishing and maintaining mitigation agreements including actions to be taken in the event of discovery of archaeological resources or human remains during construction. These agreements will be negotiated with their potentially affected tribes and state historic preservation officers. These agreements would be referenced in future site-specific National Environmental Policy Act documentation when appropriate. An example of a possible mitigation measure for archaeological resources would be avoidance or data recovery prior to construction. Other measures would be necessary to mitigate potential impacts to values of Native American or Native Hawaiian populations, including involvement in the selection of a mitigation strategy for impacts to archaeological sites, spiritual geographical features, and land use. This could include the SNF Program's participation in liaison programs to understand Native American or Native Hawaiian concerns.

For paleontological resources, assessments could include literature searches, surface surveys, and consultation with recognized paleontological experts in the region or limited test excavations in geologically similar disturbed areas. If significant paleontological resources were identified, a mitigation plan for recovery, stabilization, and caring of the resources would be implemented before construction.

For example, at the Hanford Site, certain site activities would have the potential to adversely affect prehistoric archaeological sites. In this case, the specific activity plans would be reviewed to determine potential effects before initiation of activities. The activity will then be designed to avoid these sites. If avoidance of these sites would not be possible, mitigation measures would be developed in conjunction with the appropriate state agencies and Native American tribes.

To avoid impacts during operation such as unauthorized artifact collection, workers could be educated through programs and briefing sessions to inform personnel of applicable laws and regulations for site protection. These educational programs would stress the importance of cultural resources and specifics of the laws and regulations for site protection.

5.7.4 Soils

Soils could be affected from implementation of the SNF management alternatives if there were leaks or a release to soils as a result of SNF activities. DOE would appropriately remediate any soils contaminated from SNF management activities.

5.7.5 Air Resources

Certain actions under the SNF management alternatives would impact air quality. For example, the construction of new facilities could negatively impact air quality through the emission of fugitive dusts and from pollutants from diesel- and gasoline-powered equipment. The increase in offsite ambient levels would be small because of the large distance to the nearest public access, and use of the mitigation measures described below would further minimize the potential impact.

DOE would meet applicable regulations regarding the maintenance of air quality from both radiological and nonradiological emission sources. DOE does not foresee impacts to air quality from SNF management that would warrant measures beyond those employed consistent with good construction, engineering, and operations, and management practices.

5.7.6 Water Resources

The implementation of some of the SNF management alternatives would require larger volumes of water for the stabilization of SNF. DOE would control water consumption through the appropriate application of water recycling, water conservation measures and equipment, stormwater catchment basins, and worker training programs. Constant process monitoring and mass-balance and design to current standards, including double-wall confinement of all vessels and piping, would be included in design and operating standards by DOE to limit potential operational releases from a SNF processing or storage facility to essentially zero.

5.7.7 Ecological Resources

Implementation of the SNF management alternatives could impact terrestrial resources, wetlands, aquatic resources, and threatened and endangered species either directly by earth-moving activities that disturb habitat or indirectly through construction activities that result in increased runoff into wetlands or aquatic environments.

To avoid potential impacts to endangered, candidate, or state-identified sensitive species, preconstruction surveys would be completed to determine the presence of these species or their habitat. If protected species or primary habitat for these species are located near or within an area to be disturbed, DOE would evaluate the project design and other program activities to determine if modifications would avoid negative impacts. DOE would consult with the U.S. Fish and Wildlife Service to develop the most appropriate action-specific mitigation measures.

Wetland habitat would be delineated in accordance with applicable U.S. Army Corps of Engineers procedures and wetlands located near proposed activities would be avoided. However, if avoidance were not possible, specific mitigation measures could be developed in consultation with the U.S. Army Corps of Engineers. For example, mitigation could include construction of new wetland acreage equivalent to the acreage of disturbed wetland habitat or enhancement of existing wetland habitat at another location onsite.

5.7.8 Noise

Construction and operation from SNF management would result in the generation of noise consistent with light industrial activity. DOE does not foresee noise impacts from SNF management that would warrant mitigation measures beyond those employed consistent with good construction engineering, operational, and management practices.

Noise impacts to the public and other noise-sensitive receptors could be reduced by providing noise buffer areas between sources and receptors, constructing noise walls and other attenuation structures, and limiting the emissions to daytime periods.

5.7.9 Traffic and Transportation

The number of workers in SNF management activities under some of the alternatives would add to the current work force and to additional commuting traffic. At sites with increasing traffic concerns, roads could be widened with the addition of lanes or implementation of traffic demand management. DOE would also consider using high-occupancy vehicles (such as vans or buses), implementing car-pooling or ride-sharing programs, or staggering schedules to reduce the potential for increased traffic congestion. See Section 5.7.12 for discussion of transportation accident mitigation.

5.7.10 Occupational and Public Health and Safety

Implementation of the SNF management alternatives would increase the potential for radiation exposure either through direct exposure or through air emissions. Although these effects are small, as discussed in Section 5.2, the as low as reasonably achievable principle would be used for controlling radiation exposure of workers and the public. Pollution prevention practices would be implemented to avoid or reduce production of potentially harmful substances. Waste minimization would be practiced to reduce the toxicity and volume of secondary wastes to be managed. Furthermore, sites would update their current worker training, emergency planning, emergency preparedness, and emergency response programs as needed to address new SNF management actions for the protection of both workers and the public.

5.7.11 Site Utilities and Support Services

The SNF management alternatives would put increased demands on utilities at the sites. Under certain alternatives, additional transmission lines or substations may need to be added to the infrastructure and, at the Nevada Test Site, a sewage treatment facility for the SNF management facility would need to be constructed. However, DOE would reduce the need for certain utilities (such as water and electricity) through the implementation of resource conservation, pollution prevention, and energy efficiency measures.

5.7.12 Accidents

The potential exists for an accident associated with either the handling or transportation of SNF with the consequence being a significant release of radioactive or other hazardous materials to the environment. Although the probability is very small, as discussed in Section 5.2, each of the locations considered for SNF management have emergency action plans and equipment to respond to accidents and other emergencies to limit the magnitude of potential impacts from any accident. These plans include training of workers, local emergency response agencies (such as fire departments), and the public; communication systems and protocols; readiness drills; and mutual aid agreements. The plans would be updated to cover any new SNF facilities and activities. DOE would coordinate activities with state and local agencies to establish and implement an appropriate emergency response training program for potential accidents.

5.8 Environmental Justice

In February 1994, Executive Order 12898, titled Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations (FR 1994), was released to Federal agencies. This order directs Federal agencies to incorporate environmental justice as part of their missions. As such, Federal agencies are specifically directed to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority populations and low-income populations. Appendix L of this EIS provides an assessment of the areas surrounding the 10 sites under consideration for the management of SNF under all programmatic alternatives considered in this volume. Because DOE is still in the process of developing guidance, the approach used in this analysis might depart somewhat from the guidance eventually issued.

The overall review indicated that the potential impacts calculated for each discipline under each of the alternative sites considered for the management of all or some portion of DOE SNF (or naval SNF only) present no significant risk and do not constitute a reasonably foreseeable adverse impact to the surrounding population. This includes both the impacts of facility operations and the transport of SNF, and the risk of reasonably foreseeable accident scenarios postulated for both, all of which are small. Therefore, the impacts of the programmatic management of DOE SNF under all alternatives evaluated in this EIS do not constitute a disproportionately high and adverse impact on any particular segment of the population, minorities or low-income communities included.

Characterization of the numbers and location of minority and low-income populations is dependent on how these populations are defined and what assumptions are used in conducting the analysis. As discussed in Appendix L, at the time this EIS and the Draft Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel (Draft FRR SNF EIS) were prepared, the Federal Interagency Working Group on environmental justice had not issued final guidance on the definitions of minority and low-income populations, or the approach to be used in analyzing environmental justice, as directed by the Executive Order (FR 1994). Final internal DOE guidance on environmental justice also has not been adopted. As a result, both the definitions and assumptions used by and within agencies for conducting environmental justice analyses can vary and the resulting demographic results can differ on a case-by-case basis. For example, this EIS and the Draft FRR SNF EIS present demographic characterizations derived from the same United States Census Bureau database, but these documents used different definitions and assumptions. Several of the same candidate interim SNF management sites were evaluated in both documents. As discussed in Appendix L, variations in these definitions and assumptions led to differences in the characterization of minority and low-income populations surrounding these potential interim SNF management sites. Nevertheless, although the characterizations differ, the impacts resulting from the proposed action under all alternatives present no significant risk to the population as a whole. Therefore, no disproportionately high and adverse effects would be expected for any particular segment of the population, including minority and I low-income populations, regardless of which set of definitions and assumptions were applied.

6. LIST OF PREPARERS

This EIS was prepared under the supervision of the DOE Idaho Operations Office. The organizations and individuals who contributed to the preparation of this document are listed below accompanied by each person's project role and level of experience and training. Table 6-1 at the end of this section summarizes, for each contributor, the chapters of the EIS for which inputs were prepared.

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Environmental Restoration and Waste Management Programs Environmental Impact Statement.

	Chapter											Appendix											
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Kathleen B. Whitaker	X	X	X	X			X	X	X														
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Mary V. Willcox	X	X	X	X	X	X					X		X	X	X	X	X			X	X	X	
Robert Brown											X		X	X	X	X	X						
Robert Creed, Jr.											X		X	X	X	X	X						X
Denise M. Glore								X															
Jan Hagers						X								X									
John A. Herritt											X		X	X	X	X	X						
Mark W. Howard											X		X	X	X	X	X			X			
Vicki L. Johnson	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X		X	X	
Mary McKnight								X															
Paul Martin											X		X	X	X	X	X						
John E. Medema											X		X	X	X	X	X						
William A. Owca				X																			
Mark S. Pellechi											X		X	X	X	X	X						
Ralph W. Russell											X		X	X	X	X	X						
Roger Twitchell								X			X		X	X	X	X	X						
C. Brooks Weingartner											X		X	X	X	X	X						
Science Applications International Corporation																							
Dee H. Walker	X	X	X	X										X									
Barry Nichols	X	X	X	X		X								X	X	X							
Robert D. Thomson	X	X	X	X	X	X																	

												X			
Ken Bulmahn				X	X	X						X			
Robert Cole				X		X		X	X						
Mark A. Dagel						X									
Sandy Enyeart						X									
Thomas D. Enyeart				X	X	X					X	X			
George A. Freund	X														
R. Kingsley House										X	X	X		X	
Scot R. Imus					X	X									
Irene Johnson										X	X	X			
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Anne Lundahl						X									
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Diane Morton		X	X												
Mark D. Otis						X									
Douglas Outlaw		X		X		X						X	X	X	
Howard Pippen						X						X			
Angela Sewall						X									
Donald C. Slaughterbeck						X				X	X	X	X	X	X
Patricia Swain						X									
Jane Tallman						X						X			
Jeffrey Weiler					X		X	X	X			X	X		
Tom Wierman						X						X		X	
Price L. Worrell							X					X	X		
William Wuest						X	X								
Ecology and Environment, Inc.															
Wendy Green								X							
Halliburton NUS															
Robert Abernethy											X				
Edward Agoston												X			
Adel A. Bakr											X	X			
Fred R. Bingaman, III											X	X			
Teresa L. Brandt												X	X		
James T. Chaconas												X			
Steven J. Connor											X	X			
William J. Craig												X			
Karin Crandall												X			
James Cross												X			
James Doenges											X				
J. Peyton Doub												X			
Kevin S. Dunn												X			
Alan A. Eckmyre												X			
Keven T. Folk												X			X
Edward Gorczyca												X			
Lawrence L. Greenfield												X			
Kristine A. Gunther											X	X			
Ernest C. Harr, Jr.												X	X		
Richard H. Holder						X	X				X	X		X	X
Dale T. Huls															

X
Kerry P. Humphrey
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William Hurt X
Merance A. Jacaruso
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Kathy A. Landkrohn
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Jasper G. Maltese
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Richard A. Martineit
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Louise S. Moore
X X
Philip R. Moore X
X
Aparajita S. Morrison X
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John C. Abbott X
John M. Alvis, Jr. X
Larry K. Berg X
Frances M. Berting X
Charles A. Brandt X
Mitchel E. Cunningham X
Colbert E. Cushing X
Phillip M. Daling X
James F. Donaghue X
Elizabeth A. Flores X
Stephen Gajewski X
Clifford S. Glantz X
Richard J. Guenther X
George V. Last X
John P. McDonald X
Emmett Moore X
Iral C. Nelson X

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Ronald C. Phillips                                                                    X
Kathleen Rhoads                                                                       X
Chikashi Sato                                                                         X
Dillard B. Shipler                                                                    X
Donna J. Stucky                                                                       X
Betty Tegner                                                                          X
Gene Whelan                                                                           X
Mona K. Wright                                                                        X
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X
Donald P. Doherty
X
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X           X   X   X   X   X
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X           X   X   X   X   X
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Michael A. Kuprenas                       X     X    X   X   X   X   X   X   X       X
X           X   X   X   X   X
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X           X   X   X   X   X
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Andrew N. Richardson
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Jeffrey M. Steele
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Robert H. Steele
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7. CONSULTATIONS, LAWS, AND REQUIREMENTS

7.1 Laws and Requirements

This section identifies and summarizes the major laws, regulations, executive orders, and DOE orders that may apply to the programmatic alternatives for SNF.

Section 7.1.1 discusses the major Federal statutes that impose environmental protection and compliance requirements upon DOE. In addition, there may be other Federal, state, and local measures applicable to the SNF Management Program because Federal law delegates enforcement or implementation authority to state or local agencies. These state- and local-specific requirements are addressed in the site-specific appendices. Section 7.1.2 addresses environmentally-related presidential executive orders that clarify issues of national policy and set guidelines under which Federal agencies, including DOE, must act. DOE implements its responsibilities for protection of public health, safety, and the environment through a series of departmental orders that are mandatory for operating contractors of DOE facilities. Section 7.1.3 discusses those DOE orders related to environmental, health, and safety protection. Hazardous and radioactive materials transportation regulations are summarized in Section 7.1.4.

7.1.1 Federal Environmental Statutes and Regulations

National Environmental Policy Act of 1969, as amended (42 USC -4321 et seq.) The National Environmental Policy Act establishes a national policy promoting awareness of the environmental consequences of the activity of humans on the environment and promoting consideration of the environmental impacts during the planning and decisionmaking stages of a project. The National Environmental Policy Act requires all agencies of the Federal Government to prepare a detailed statement on the environmental effects of proposed major Federal actions that may significantly affect the quality of the human environment.

This EIS has been prepared in response to these National Environmental Policy Act requirements and policies. It discusses reasonable alternatives and their potential environmental consequences of proposed SNF activities at various locations in the country and has been prepared in accordance with the Council on Environmental Quality Regulations for implementing the procedural provisions of the National Environmental Policy Act Implementing Procedures (40 CFR Parts 1500 through 1508) and DOE National Environmental Policy Act Implementing Procedures (10 CFR Part 1021).

Atomic Energy Act of 1954, as amended (42 USC -2011 et seq.). The Atomic Energy Act of 1954 authorizes DOE to establish standards to protect health or minimize dangers to life or property with respect to activities under its jurisdiction. Through a series of DOE orders, DOE has established an extensive system of standards and requirements to ensure safe operation of its facilities.

The Atomic Energy Act and the Reorganization Plan No. 3 of 1970 [5 USC (app. at 1343)] and other related statutes gave the U.S. Environmental Protection Agency responsibility and authority for developing generally applicable environmental standards for protection of the general environment from radioactive material. The U.S. Environmental Protection Agency has promulgated several regulations under this authority, among which are the Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes, at 40 CFR Part 191.

Nuclear Waste Policy Act of 1982, as amended, (42 USC -10101-10270). The Act authorizes the Federal agencies to develop a geologic repository for the permanent disposal of SNF and high-level radioactive waste. The Act specifies the process for selecting a repository site and constructing, operating, closing, and decommissioning the repository. The Act also establishes programmatic guidance for these activities.

Clean Air Act, as amended (42 USC -7401 et seq.). The Clean Air Act, as amended, is intended to "protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare and the productive capacity of its population." Section 118 of the Clean Air Act, as amended, requires that each Federal agency, such as DOE, with jurisdiction over any property or facility that might result in the discharge of air pollutants, comply with "all Federal, state, interstate, and local requirements" with regard to the control and abatement of air pollution.

The Act requires the U.S. Environmental Protection Agency to establish National Ambient Air Quality Standards as necessary to protect public health, with an adequate margin of safety, from any known or anticipated adverse effects of a regulated pollutant (42 USC -7409). The Act also requires establishment of national standards of performance for new or modified stationary sources of atmospheric pollutants (42 USC -7411) and requires specific emission increases to be evaluated so as to prevent a significant deterioration in air quality (42 USC -7470). Hazardous air pollutants, including radionuclides, are regulated separately (42 USC -7412). Air emissions are regulated by the U.S. Environmental Protection Agency in 40 CFR Parts 50 through 99. In particular, radionuclide emissions and hazardous air pollutants are regulated under the National Emission Standard for Hazardous Air Pollutants Program (see 40 CFR Part 61 and 40 CFR Part 63).

Safe Drinking Water Act, as amended [42 USC -300 (F) et seq.]. The primary objective of the Safe Drinking Water Act, as amended, is to protect the quality of the public water supplies and all sources of drinking water. The implementing regulations, administered by the U.S. Environmental Protection Agency unless delegated to the states, establish standards applicable to public water systems. They promulgate maximum contaminant levels, including those for radioactivity, in public water systems, which are defined as public water systems that serve at least 15 service connections used by year-round residents or regularly serve at least 25 year-round residents. Safe Drinking Water Act requirements have been promulgated by the U.S. Environmental Protection Agency in 40 CFR Parts 100 through 149. For radionuclides, the regulations in effect now specify that the average annual concentration of beta particle and photon radioactivity from manmade radionuclides in drinking water shall not produce an annual dose equivalent to the total body or any internal organ greater than 0.004 rem (4 millirem)/year. The maximum contaminant level for gross alpha particle activity is 15 picocuries per liter. The U.S. Environmental Protection Agency proposed revisions to limits on regulating radionuclides July 18, 1991. The proposed rule has not been finalized. For purposes of analysis, however, the more conservative standards were used. Other programs established by the Safe Drinking Water Act include the Sole Source Aquifer Program, the Wellhead Protection Program, and the Underground Injection Control Program.

Clean Water Act, as amended (33 USC -1251 et seq.). The Clean Water Act, which amended the Federal Water Pollution Control Act, was enacted to "restore and maintain the chemical, physical and biological integrity of the Nation's water." The Clean Water Act prohibits the "discharge of toxic pollutants in toxic amounts" to navigable waters of the United States. Section 313 of the Clean Water Act, as amended, requires all branches of the Federal Government engaged in any activity that might result in a discharge or runoff of pollutants to surface waters to comply with Federal, state, interstate, and local requirements.

In addition to setting water quality standards for the Nation's waterways, the Clean Water Act supplies guidelines and limitations for effluent discharges from point-source discharges and provides authority for the U.S. Environmental Protection Agency to implement the National Pollutant Discharge

Elimination System permitting program. The National Pollutant Discharge Elimination System program is administered by the Water Management Division of the U.S. Environmental Protection Agency pursuant to regulations in 40 CFR Part 122 et seq. Idaho has not applied for National Pollutant Discharge Elimination System authority from the U.S. Environmental Protection Agency. Thus, all National Pollutant Discharge Elimination System permits required for the Idaho National Engineering Laboratory are obtained by DOE through the U.S. Environmental Protection Agency Region 10 (40 CFR Part 122 et seq.).

Sections 401 and 405 of the Water Quality Act of 1987 added Section 402(p) to the Clean Water Act. Section 402(p) requires that the Environmental Protection Act establish regulations for issuing permits for stormwater discharges associated with industrial activity. Stormwater discharges associated with industrial activity are permitted through the National Pollutant Discharge Elimination System. General Permit requirements are published at 40 CFR Part 122.

Resource Conservation and Recovery Act, as amended (42 USC -6901 et seq.). The treatment, storage, or disposal of hazardous and nonhazardous waste is regulated under the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act and the Hazardous and Solid Waste Amendments of 1984. Pursuant to Section 3006 of the Act, any state that seeks to administer and enforce a hazardous waste program pursuant to the Resource Conservation and Recovery Act may apply for U.S. Environmental Protection Agency authorization of its program. The U.S. Environmental Protection Agency regulations implementing the Resource Conservation and Recovery Act are found in 40 CFR Parts 260 through 280. These regulations define hazardous wastes and specify hazardous waste transportation, handling, treatment, storage, and disposal requirements.

The regulations imposed on a generator or a treatment, storage, and/or disposal facility vary according to the type and quantity of material or waste generated, treated, stored, and/or disposed of. The method of treatment, storage, and/or disposal also impacts the extent and complexity of the requirements (see also Section 7.2.5).

Comprehensive Environmental Response, Compensation, and Liability Act, as amended (42 USC -9601 et seq.). The Comprehensive Environmental Response, Compensation, and Liability Act, as amended, provides a statutory framework for the cleanup of waste sites containing hazardous substances and-as amended by the Superfund Amendments and Reauthorization Act-provides an emergency response program in the event of a release (or threat of a release) of a hazardous substance to the environment. Using the Hazard Ranking System, Federal and private sites are ranked and may be included on the National Priorities List. The Comprehensive Environmental Response, Compensation, and Liability Act, as amended, requires such Federal facilities having such sites to undertake investigations and remediation as necessary. The Act also includes requirements for reporting releases of certain hazardous substances in excess of specified amounts to state and Federal agencies.

Emergency Planning and Community Right-to-Know Act of 1986 (42 USC -11001 et seq.) (also known as "SARA Title III"). Under Subtitle A of this Act, Federal facilities, including those owned by DOE, provide various information (such as inventories of specific chemicals used or stored and releases that occur from these sites) to the State Emergency Response Commission and to the Local Emergency Planning Committee to ensure that emergency plans are sufficient to respond to unplanned releases of hazardous substances. Implementation of the provisions of this Act began voluntarily in 1987, and inventory and annual emissions reporting began in 1988 based on 1987 activities and information. DOE also requires compliance with Title III as matter of Agency policy. The requirements for this Act were promulgated by the U.S. Environmental Protection Agency in 40 CFR Parts 350 through 372.

Toxic Substances Control Act (15 USC -2601 et seq.). The Toxic Substances Control Act provides the U.S. Environmental Protection Agency with the authority to require testing of chemical substances, both new and old, entering the environment, and regulates them where necessary. The law complements and expands existing toxic substance laws such as -112 of the Clean Air Act and -307 of the

Clean Water Act. The Toxic Substances Control Act came about because there were no general Federal regulations for the potential environmental or health effects of the thousands of new chemicals developed each year before they were introduced into the public or commerce. The Toxic Substances Control Act also regulates the treatment, storage, and disposal of certain toxic substances, specifically polychlorinated biphenyls, chlorofluorocarbons, asbestos, dioxins, certain metal-working fluids, and hexavalent chromium. The asbestos regulations under the Toxic Substances Control Act were ultimately overturned. However, regulations pertaining to asbestos removal, storage, and disposal are promulgated through the National Emission Standard for Hazardous Air Pollutants Program (40 CFR Part 61, Subpart M). For chlorofluorocarbons, Title VI of the Clean Air Act Amendments of 1990 requires a reduction of chlorofluorocarbons beginning 1991, and prohibits production beginning 2000.

Pollution Prevention Act of 1990 (42 USC -13101 et seq.). The Pollution Prevention Act of 1990 establishes a national policy for waste management and pollution control that focuses first on source reduction, followed sequentially by environmentally safe recycling, treatment, and lastly, disposal. Disposal or releases to the environment should only occur as a last resort. In response, DOE has committed to participation in the Superfund Amendments and Reauthorization Act Section 313, U.S. Environmental Protection Agency 33/50 Pollution Prevention Program. The goal, for facilities already involved in Section 313 compliance, is to achieve a 33 percent reduction in the release of 17 priority chemicals by 1997, from a 1993 baseline. On August 3, 1993, Executive Order 12856 was issued, expanding the 33/50 program such that DOE must reduce its total releases of all toxic chemicals by 50 percent by December 31, 1999. The DOE is also requiring each DOE site to establish site-specific goals to reduce generation of all waste types.

Federal Facility Compliance Act. The Federal Facility Compliance Act, enacted on October 6, 1992, waives sovereign immunity for fines and penalties for Resource Conservation and Recovery Act violations at Federal facilities. However, a provision postpones fines and penalties after 3 years for mixed waste storage prohibition violations at DOE sites and requires DOE to prepare plans for developing the required treatment capacity for mixed waste stored or generated at each facility. Each plan must be approved by the host state or the U.S. Environmental Protection Agency, after consultation with other affected states, and a consent order must be issued by the regulator requiring compliance with the plan. The Federal Facility Compliance Act further provides that the DOE will not be subject to fines and penalties for land disposal restriction storage prohibition violations for mixed waste as long as it is in compliance with such an approved plan and consent order and meets all other applicable regulations.

National Historic Preservation Act, as amended (16 USC -470 et seq.). The National Historic Preservation Act, as amended, provides that sites with significant national historic value be placed on the National Register of Historic Places. There are no permits or certifications required under the Act. However, if a particular Federal activity may impact a historic property resource, consultation with the Advisory Council on Historic Preservation will generally generate a Memorandum of Agreement, including stipulations that must be followed to minimize adverse impacts. Coordinations with the State Historic Preservation officer are also undertaken to ensure that potentially significant sites are properly identified and appropriate mitigative actions are implemented.

Archaeological Resource Protection Act, as amended (16 USC -470aa et seq.). This Act requires a permit for any excavation or removal of archaeological resources from public or Indian lands. Excavations must be undertaken for the purpose of furthering archaeological knowledge in the public interest, and resources removed are to remain the property of the United States. Consent must be obtained from the Indian tribe owning lands on which a resource is located before issuance of a permit, and the permit must contain terms or conditions requested by the tribe.

Native American Grave Protection and Repatriation Act of 1990 (25 USC -3001). This law directs the Secretary of Interior to guide responsibilities in repatriation of Federal archaeological collections and collections held by museums receiving Federal funding that are culturally affiliated to Native American tribes. Major actions to be taken under this law include (a) establishing a review committee with monitoring and policy-making responsibilities, (b) developing regulations for repatriation, including procedures for identifying lineal descent or cultural affiliation needed for claims, (c) oversight of museum programs designed to meet the inventory requirements and deadlines of this law, and (d) developing procedures to handle unexpected discoveries of graves or grave goods during activities on Federal or tribal land.

American Indian Religious Freedom Act of 1978 (42 USC -1996). This act reaffirms Native American religious freedom under the First Amendment and sets United States policy to protect and preserve the inherent and constitutional right of American Indians to believe, express, and exercise their traditional religions. The act requires that Federal actions avoid interfering with access to sacred locations and traditional resources that are integral to the practice of religions.

Religious Freedom Restoration Act of 1993 (42 USC -2000bb et seq.). This Act prohibits the Government, including Federal departments, from substantially burdening the exercise of religion unless the Government demonstrates a compelling governmental interest and the action furthers a compelling Government interest and is the least restrictive means of furthering that interest.

Endangered Species Act, as amended (16 USC -1531 et seq.). The Endangered Species Act, as amended, is intended to prevent the further decline of endangered and threatened species and to restore these species and their habitats. The Act is jointly administered by the U.S. Departments of Commerce and the Interior. Section 7 of the Act requires consultation with the U.S. Fish and Wildlife Service to determine whether endangered and threatened species or their critical habitats are known to be in the vicinity of the proposed action.

Migratory Bird Treaty Act, as amended (16 USC -703 et seq.). The Migratory Bird Treaty Act, as amended, is intended to protect birds that have common migration patterns between the United States and Canada, Mexico, Japan, and Russia. It regulates the harvest of migratory birds by specifying things such as the mode of harvest, hunting seasons, and bag limits. The Act stipulates that it is unlawful at any time, by any means, or in any manner to "kill . . . any migratory bird." Although no permit for this project is required under the Act, DOE is required to consult with the U.S. Fish and Wildlife Service regarding impacts to migratory birds and to evaluate ways to avoid or minimize these effects in accordance with the U.S. Fish and Wildlife Service Mitigation Policy.

Bald and Golden Eagle Protection Act, as amended (16 USC -668-668d). The Bald and Golden Eagle Protection Act makes it unlawful to take, pursue, molest, or disturb bald (American) and golden eagles, their nests, or their eggs anywhere in the United States (Section 668, 668c). A permit must be obtained from the U.S. Department of the Interior to relocate a nest that interferes with resource development or recovery operations.

Wild and Scenic Rivers Act, as amended (16 USC 1271 et seq. 71:8301 et seq.). The Wild and Scenic Rivers Act, as amended, protects certain selected rivers of the Nation, which possess outstanding scenic, recreational, geological, fish and wildlife, historical, cultural, or other similar values. These rivers are to be preserved in a free-flowing condition to protect water quality and other vital national conservation purposes. The purpose of the Act is to institute a national wild and scenic rivers system, to designate the initial rivers that are a part of that system, and to develop standards for the addition of new rivers in the future.

Occupational Safety and Health Act of 1970, as amended (29 USC -651 et seq.). The Occupational Safety and Health Act establishes standards to enhance safe and healthful working conditions in places of employment throughout the United States. The Act is administered and enforced by the Occupational Safety and Health Administration, a U.S. Department of Labor agency. While the Occupational Safety and Health Administration and the U.S. Environmental Protection Agency both have a mandate to reduce exposures to toxic substances, the Occupational Safety and Health Administration's jurisdiction is limited to safety and health conditions that exist in the workplace environment.

In general, under the Act, it is the duty of each employer to furnish all employees a place of employment free of recognized hazards likely to cause death or serious physical harm. Employees have a duty to comply with the occupational safety and health standards and all rules, regulations, and orders issued under the Act. Occupational Safety and Health Administration regulations (published in Title 29 of the Code of Federal Regulations) establish specific standards telling employers what must be done to achieve a safe and healthful working environment. DOE places emphasis on compliance with these regulations at DOE facilities and prescribes through DOE orders the Occupational Safety and Health Act standards that contracts shall meet, as applicable to their work at Government-owned, contractor-operated facilities (DOE Order 5480.1B, 5483.1A). DOE keeps and makes available the various records of minor illnesses, injuries, and work-related deaths as required by Occupational Safety and Health Administration regulations.

Noise Control Act of 1972, as amended (42 USC -4901 et seq.). Section 4 of the Noise Control Act of 1972, as amended, directs all Federal agencies to carry out "to the fullest extent within their authority" programs within their jurisdictions in a manner that furthers a national policy of promoting an environment free from noise that jeopardizes health and welfare.

7.1.2 Executive Orders

Executive Order 12088 (Federal Compliance with Pollution Control Standards) (October 13, 1978), as amended by Executive Order 12580 (January 23, 1987) Federal Compliance with Pollution Control Standards, directs Federal agencies, including DOE, to comply with applicable administrative and procedural pollution control standards established by, but not limited to, the Clean Air Act, the Noise Control Act, the Clean Water Act, the Safe Drinking Water Act, the Toxic Substances Control Act (15 USC -2061 et seq.), and the Resource Conservation and Recovery Act.

Executive Order 11593 (National Historic Preservation) (May 13, 1971) directs Federal agencies, including DOE, to locate, inventory, and nominate properties under their jurisdiction or control to the National Register of Historic Places if those properties qualify. This process requires DOE to provide the Advisory Council on Historic Preservation the opportunity to comment on the possible impacts of the proposed activity on any potential eligible or listed resources.

Executive Order 11514 (National Environmental Policy Act) directs Federal agencies to continually monitor and control their activities to protect and enhance the quality of the environment and to develop procedures to ensure that fullest practicable provision of timely public information and understanding of the Federal plans and programs with environmental impact to obtain the views of interested parties. The DOE has issued regulations (10 CFR Part 1021) and DOE Order 5440.1E for compliance with this executive order.

Executive Order 11988 (Floodplain Management) directs Federal agencies to establish procedures to ensure that the potential effects of flood hazards and floodplain management are considered for any action undertaken in a floodplain and that floodplain impacts be avoided to the extent practicable.

Executive Order 11990 (Protection of Wetlands) directs governmental agencies to avoid, to the extent practicable, any short- and long-term adverse impacts on wetlands wherever there is a practicable alternative.

Executive Order 12344 (Naval Nuclear Propulsion Program) [enacted as permanent law by Public Law 98-525 (42 USC -7158)] prescribes the authority and responsibility of the Naval Nuclear Propulsion Program, a joint Navy/DOE organization, for matters pertaining to Naval nuclear propulsion. These responsibilities include all environmental and occupational safety and health aspects of the program.

Executive Order 12580 (Superfund Implementation) delegates to the heads of executive departments and agencies the responsibility for undertaking remedial actions for releases, or threatened releases that are not on the National Priority List and removal actions other than emergencies where the release is from any facility under the jurisdiction or control of executive departments and agencies.

Executive Order 12856 (Right to Know Laws and Pollution Prevention Requirements) This order directs all Federal agencies to reduce and report toxic chemicals entering any wastestream; improve emergency planning, response, and accident notification; and encourage clean technologies and testing of innovative prevention technologies. The executive order also provides that Federal agencies are persons for purposes of the Emergency Planning and Community Right-to-Know Act (SARA Title III), which obliges agencies to meet the requirements of the Act.

Executive Order 12898 (Environmental Justice) This order directs Federal agencies to achieve environmental justice by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions. The order creates an Interagency Working Group on Environmental Justice and directs each Federal agency to develop strategies within prescribed time limits to identify and address environmental justice concerns. The order further directs each Federal agency to collect, maintain, and analyze information on the race, national origin, income level, and other readily accessible and appropriate information for areas surrounding facilities or sites expected to have a substantial environmental, human health, or economic effect on the surrounding populations, when such facilities or sites become the subject of a substantial Federal environmental administrative or judicial action and to make such information publicly available.

Executive Order 12114 (Environmental Effects Abroad of Major Federal Actions) This order declares that Federal agencies are required to prepare environmental analyses for "major Federal actions significantly affecting the environment of the global commons outside the jurisdiction of any nation (e.g., the ocean or Antarctica)." According to the Executive Order, major Federal actions significantly affecting the environment of foreign countries may also require environmental analyses under certain circumstances. The procedural requirements imposed by the Executive Order are analogous to those under the National Environmental Policy Act.

7.1.3 Department of Energy Regulations and Orders

Through the authority of the Atomic Energy Act, DOE is responsible for establishing a comprehensive health, safety, and environmental program for its facilities. The regulatory mechanisms through which DOE manages its facilities are the promulgation of regulations and the issuance of DOE orders.

The DOE regulations are generally found in Title 10 of the Code of Federal Regulations. These regulations address such areas as energy conservation, administrative requirements and procedures, nuclear safety, and classified information. For purposes of this EIS, relevant regulations include 10 CFR Part 820, Procedures for DOE Nuclear Activities; 10 CFR Part 830.120, Quality Assurance; 10 CFR Part 834, Radiation Protection of the Public and the Environment (proposed); 10 CFR Part 835, Occupational Radiation Protection; 10 CFR Part 1021, Compliance with the National Environmental Policy Act; and 10 CFR Part 1022, Compliance with Floodplains/ Wetlands Environmental Review Requirements.

DOE orders generally set forth policy and the programs and internal procedures for implementing those policies. The major DOE orders pertaining to the eventual construction and operation of SNF facilities within the DOE Complex are listed in Table 7-1. The following sections provide a brief discussion of selected orders:

DOE Order 5440.1E, National Environmental Policy Act Compliance Program. This order establishes authorities and responsibilities of DOE officials and sets forth internal procedures for implementing the National Environmental Policy Act. This order was issued by DOE on November 10, 1992.

DOE Order 5480.1B, Environment Safety and Health Program for Department of

Energy Operations. This order establishes the Environment, Safety and Health Program for DOE operations.

7.1.4 Hazardous and Radioactive Materials Transportation Regulations

Transportation of hazardous and radioactive materials, substances, and wastes are governed by the U.S. Department of Transportation, U.S. Nuclear Regulatory Commission, and U.S. Environmental Protection Agency regulations. These regulations may be found in 49 CFR Parts 171 through 178, 49 CFR Parts 383 through 397, 10 CFR Part 71, and 40 CFR Part 262, respectively.

U.S. Department of Transportation regulations contain requirements for identifying a material as hazardous or radioactive. These regulations interface with those of the U.S. Nuclear Regulatory Commission or U.S. Environmental Protection Agency regulations for identifying material, but the U.S. Department of Transportation hazardous material regulations govern the hazard communication (such as marking, hazard labelling, vehicle placarding, and emergency response telephone number) and shipping requirements (such as required entries on shipping papers or U.S. Environmental Protection Agency waste manifests).

Table 7-1. DOE orders relevant to the DOE Spent Nuclear Fuel Management Program.

DOE Order	Subject
1300.2A	Department of Energy Technical Standards Program (5-19-92)
1360.2B	Unclassified Computer Security Program (5-18-92)
1540.2	Hazardous Material Packaging for Transport-Administrative Procedures (9-30-86; Chg. 1, 12-19-88)
3790.1B	Federal Employee Occupational Safety and Health Program (1-7-93)
4330.4B	Maintenance Management Program (2-10-94)
4700.1	Project Management System (3-6-87; Chg. 1, 6-2-92)
5000.3B	Occurrence Reporting and Processing of Operations Information (1-19-93; Chg. 1, 7-2-93)
5400.1	General Environmental Protection Program (11-9-88; Chg. 1, 6-29-90)
5400.2A	Environmental Compliance Issue Coordination (1-31-89; Chg.1, 1-7-93)
5400.4	Comprehensive Environmental Response, Compensation, and Liability Act Requirements (10-6-89)
5400.5	Radiation Protection of the Public and the Environment (2-8-90; Chg. 2, 1-7-93)
5440.1E	National Environmental Policy Act Compliance Program (11-10-92)
5480.1B	Environment, Safety and Health Program for DOE Operations (9-23-86; Chg. 5, 5-10-93)
5480.3	Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes (7-9-85)
5480.4	Environmental Protection, Safety, and Health Protection Standards (5-15-84; Chg. 4, 1-7-93)
5480.6	Safety of Department of Energy-Owned Nuclear Reactors (09-23-86)
5480.7A	Fire Protection (2-17-93)
5480.8A	Contractor Occupational Medical Program (6-26-92; Chg. 1, 10-19-92)
5480.9A	Construction Project Safety and Health Management (4-13-94)
5480.10	Contractor Industrial Hygiene Program (6-26-85)
5480.11	Radiation Protection for Occupational Workers (12-21-88; Chg. 3, 6-17-92)
5480.15	Department of Energy Laboratory Accreditation Program for Personnel Dosimetry (12-14-87)
5480.17	DOE Site Safety Representatives (10-05-88)
5480.18B	Nuclear Facility Training Accreditation Program (08-31-94)
5480.19	Conduct of Operations Requirements for DOE Facilities (7-9-90; Chg. 1, 5-18-92)
5480.20	Personnel Selection, Qualification, Training, and Staffing Requirements at DOE Reactor and Nonreactor Nuclear Facilities (2-20-91; Chg. 1, 6-19-91)
5480.21	Unreviewed Safety Questions (12-24-91)
5480.22	Technical Safety Requirements (2-25-92; Chg. 1, 9-15-92)
5480.23	Nuclear Safety Analysis Reports (4-30-92; Chg. 1, 3-10-94)
5480.24	Nuclear Criticality Safety (8-12-92)
5480.28	Natural Phenomena Hazards Mitigation (1-15-93)
5480.31	Startup and Restart of Nuclear Facilities (9-15-93)
5481.1B	Safety Analysis and Review System (9-23-86; Chg. 1, 5-19-87)
5482.1B	Environment, Safety, and Health Appraisal Program (9-23-86; Chg. 1, 11-18-91)
5483.1A	Occupational Safety and Health Program for DOE Contractor Employees at Government-Owned, Contractor-Operated Facilities (6-22-83)
5484.1	Environmental Protection, Safety, and Health Protection Information Reporting Requirements (2-21-81; Chg. 7, 10-17-90)
5500.1B	Emergency Management System (4-30-91; Chg. 1, 2-27-92)
5500.2B	Emergency Categories, Classes, and Notification and Reporting Requirements (4-30-91; Chg. 1, 2-27-92)

5500.3A	Planning and Preparedness for Operational Emergencies (4-30-91; Chg. 1, 2-27-92)
5500.4A	Public Affairs Policy and Planning Requirements for Emergencies (6-8-92)
5500.7B	Emergency Operating Records Protection Program (10-23-91)
5500.10	Emergency Readiness Assurance Program (4-30-91; Chg. 1, 2-27-92)
5630.11B	Safeguards and Security Program (8-2-94)
5630.12A	Safeguards and Security Inspection and Assessment Program (6-23-92)
5700.6C	Quality Assurance (8-21-91)
5820.2A	Radioactive Waste Management (9-26-88)
6430.1A	General Design Criteria (4-6-89)

U.S. Nuclear Regulatory Commission regulations applicable to radioactive materials transportation are found in 10 CFR Part 71, which includes detailed packaging design requirements and package certification testing requirements. Complete documentation of design and safety analysis and results of the required testing is submitted to the U.S. Nuclear Regulatory Commission to certify the package for use. This certification testing involves the following components: heat, physical drop onto an unyielding surface, water submersion, puncture by dropping package onto a rigid spike, and gas tightness. Some of the required tests simulate maximum reasonably foreseeable accident conditions.

U.S. Environmental Protection Agency regulations pertaining to hazardous waste transportation are found in 40 CFR Part 262. These regulations deal with the use of the U.S. Environmental Protection Agency waste manifest, which is the shipping paper for transporting Resource Conservation and Recovery Act hazardous waste.

7.1.5 Applicability of the Resource Conservation and Recovery Act to Spent Nuclear Fuel

Historically, DOE chemically reprocessed SNF to recover valuable products and fissionable materials, and as such, the SNF was not a solid waste under the Resource Conservation and Recovery Act.

World events have resulted in significant changes in DOE's direction and operations. In particular, in April 1992 DOE announced the phase-out of reprocessing for the recovery of special nuclear materials. With these changes, DOE's focus on most of its SNF has changed from reprocessing and recovery of materials to storage and ultimate disposition. This in turn has created uncertainty in regard to the regulatory status of some of DOE's SNF relative to the Resource Conservation and Recovery Act.

DOE has initiated discussion with the U.S. Environmental Protection Agency on the potential applicability of the Resource Conservation and Recovery Act to SNF. Further discussions with U.S. Environmental Protection Agency Headquarters and regional offices and state regulators are ongoing to develop a path forward toward meeting any Resource Conservation and Recovery Act requirements that might apply.

7.2 Consultation

The National Environmental Policy Act requires that Federal, state, and local agencies with jurisdiction or special expertise regarding any environmental impact be consulted and involved in the National Environmental Policy Act process. Agencies involved include those with authority to issue applicable permits, licenses, and other regulatory approvals, as well as those responsible for protecting significant resources (for example, endangered species, critical habitats, or historic resources). These agencies will be sent copies of the Final EIS.

Consultations with Federal and state agencies and native America tribes were initiated by DOE. Table 7-2 shows the dates and locations of the meetings held. Volume 2, Appendix B, contains meeting correspondence generated as a result of these meetings.

Table 7-2. Meetings held in response to agency or nation comments on the Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory

Environmental Restoration and Waste Management Programs Draft Environmental Impact Statement.

Agency or nation	Location	Date
Defense Nuclear Facilities Safety Board	Washington, D.C.	November 9, 1994
U.S. Environmental Protection Agency	Washington, D.C.	December 15, 1994
Center for Disease Control	Conference call	November 22, 1994
Council on Environmental Quality	Washington, D.C.	December 21, 1994
Seneca Nation of New York	New York	January 10, 1995
Shoshone-Bannock Tribes of Idaho	Fort Hall, Idaho	December 2,21, and 29, 1994 January 10, 1995 February 13, 1995

8. INDEX

Subjects are indexed by section, figure, table, and appendix designations only.

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APPENDIX A Hanford Site Spent Nuclear Fuel Management Program

Department of Energy Programmatic
Spent Nuclear Fuel Management
and
Idaho National Engineering Laboratory
Environmental Restoration and
Waste Management Programs
Final Environmental Impact Statement
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Appendix A
Hanford Site
Spent Nuclear Fuel Management Program
April 1995
U.S. Department of Energy
Office of Environmental Management
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1. INTRODUCTION

The U.S. Department of Energy (DOE) is currently deciding the direction of its environmental restoration and waste management programs at the Idaho National Engineering Laboratory (INEL) for the next 10 years. Pertinent to this decision is establishing policies for the environmentally sensitive and safe transport, storage, and management of spent nuclear fuels (SNF). To develop these policies, it is necessary to revisit or examine the available options.

As a part of the DOE complex, the Hanford Site not only has a large portion of the nationwide DOE-owned inventory of SNF, but also is a participant in the DOE decision for management and ultimate disposition of SNF. Efforts in this process at Hanford include assessment of several options for stabilizing, transporting, and storing all or portions of DOE-owned SNF at the Hanford Site. Such storage and management of SNF will be in a safe and suitable manner until a final decision is made for ultimate disposition of SNF. The Hanford Site will be affected by the alternative chosen.

Five alternatives involving the Hanford Site are being considered for management of the SNF inventory: 1) the No Action Alternative, 2) the Decentralization Alternative, 3) the 1992/1993 Planning Basis Alternative, 4) the Regionalization Alternative, and 5) the Centralization Alternative. All alternatives will be carefully designed to avoid environmental degradation and to provide protection to human health and safety at the Hanford Site and surrounding region. For Hanford, these alternatives are briefly summarized below:

- No Action Alternative -- The No Action Alternative would preclude any additional transportation of SNF to or from Hanford but could include activities to maintain safe and secure materials and facilities. Hanford SNF would continue to be managed in the current mode and upgrade of existing facilities would occur only as required to ensure safety and security.
- Decentralization Alternative -- The Decentralization Alternative would require that DOE-owned fuel be managed at the location where it is removed from the reactor. Hanford SNF would be safely stored, with some limited onsite relocation of SNF. To accommodate this mission, existing facilities would be upgraded and new storage systems would be constructed.
- 1992/1993 Plannin~ Basis -- SNF would continue to be managed in the current mode, which includes upgrades, fuel stabilization, transport of some SNF to either INEL or Savannah River Site for storage, and construction of an SNF storage facility at Hanford.
- Regionalization Alternative -- The Regionalization Alternative contains options that range from storing all SNF west of the Mississippi River including Naval

SNF, to shipping all Hanford SNF offsite to either INEL or the Nevada Test Site. Existing facilities would be upgraded and new storage systems constructed, as in the Decentralization Alternative for SNF storage at Hanford, or packaging facilities would be constructed as in the Centralization (Minimum) Alternative for offsite shipment.

- Centralization Alternative -- The Centralization Alternative has two major options. Either all Hanford SNF would be shipped offsite to another location where all SNF would be centralized (minimum option), or the Hanford Site would become the centralized location (maximum option) for all DOE SNF to be stored until ultimate disposition.

The Spent Fuel Working Group Report (DOE 1993a) identified deficiencies related to existing SNF management at the various DOE sites. Most of these deficiencies result from degradation of the fuel and the facilities that store fuel because 6f the age of these facilities and the fuel storage conditions. Corrective actions to the identified deficiencies for each site, including the Hanford Site, are listed in DOE (1994a). Hanford Site corrective actions important to this EIS include the following:

1. alternative containerization of fuel stored in the 105-KE Basin to isolate a potential pathway of fuel constituents to the environment

2. preparation of a K Basins ElS and issuance of the record of decision to provide for management of SNF in the K Basins at the Hanford Site (SNF storage siting and configuration, path forward for ultirnate disposition, etc.)

3. removal of all fuel and sludge from the K Basins by December 2002 based on the K Basins ElS record of decision

4. technical evaluation and characterization of N Reactor fuel to support development of the K Basins EIS

5. removal of fuel from the Fast Flux Test Facility; the Plutonium and Uranium Recovery through EXtraction (PUREX) Plant; the 308 Building; the 324, 325, and 327 buildings; T Plant; and the 200-West Area Low-Level Burial Grounds to support prolonged safe, economic, environmentally sound management of those fuels.

On-going corrective actions with prior National Environmental Policy Act (NEPA) coverage, such as containerization of fuel in the 105-KE Basin, are included in the No Action Alternative. Other corrective actions are included within the scope of each of the remaining alternatives. The impacts of continued fuel and facility degradation in the No Action Alternative are not fully quantified, although it is generally recognized that prolonged storage in the existing facilities for an additional 40-year period might represent unacceptable risks, as reflected in DOE (1993a).

The Hanford Site portion of this ElS was prepared according to the National Environmental Policy Act (NEPA) of 1969, as amended; the Council on Environmental Quality (CEO) regulations (40 CFR Part 1500-1308) for the implementation of the NEPA; and DOE regulations (10 CFR 1021) that supplement the CEO regulations. This document discusses five alternatives for the management and storage of SNF, the affected environment, and potential impacts of the alternatives.

2. BACKGROUND

2.1 Hanford Site Overview

2.1.1 Site Description

The U.S. Department of Energy's Hanford Site lies within the semiarid Pasco Basin of the

Columbia Plateau in southeastern Washington State (Figure- 2.1). The Hanford Site occupies an area of about 1450 square kilometers (560 square miles) north of the confluence of the Yakima River with the Columbia River. The Hanford Site is about 50 kilometers (30 miles) north to south and 40 kilometers (24 - miles) east to west. This land, with restricted public access, provides a buffer for the smaller areas previously used for production of nuclear materials, and currently used for research, waste management and disposal, and environmental restoration; only about 6 percent of the land area has been disturbed and is actively used. The Columbia River flows through the northern part of the Hanford Site, and turning south, it forms part of the site's eastern boundary. The Yakima River runs near the southern boundary and joins the Columbia River south of the city of Richland, which bounds the Hanford Site on the southeast. Rattlesnake Mountain, the Yakima Ridge, and the Umptanum Ridge form the southwestern and western boundary. The Saddle Mountains form the northern boundary of the Hanford Site. Two small east-west ridges, Gable Butte and Gable Mountain, rise above the plateau of the central part of the Hanford Site. Underneath the Hanford Site are ancient basaltic flows with basaltic outcroppings on the surface and intermixed beds of sand and gravel from ancient periods of flooding and glacial epochs. Adjoining lands to the west, north, and east are principally range and agricultural land. The cities of Richland, Kennewick, and Pasco (Tri-Cities) constitute the nearest population center and are located southeast of the Hanford Site.

The Hanford Site is listed on the National Priorities List under the Comprehensive Environmental Response, Compensation, and Liability Act. The site encompasses more than 1500 waste management units and four groundwater contamination plumes that have been grouped into 78 operable units. Each unit has complementary characteristics of such parameters as geography, waste characteristics, type of facility, and relationship of contaminant plumes. This grouping into operable units allows for economies of scale to reduce the cost and the number of characterization investigations and remedial actions that will be required for the Hanford Site to complete cleanup efforts. More information on the locations of the units is included in Section 4.1. Current maps showing the locations of the operable units can be obtained from Westinghouse Hanford Company.

Figure 2-1. Hanford Site and vicinity.

2.1.2 History

The Hanford Site was acquired by the federal government in 1943. For more than 20 years, Hanford Site facilities were dedicated primarily to the production of plutonium for national defense and to the management of the resulting wastes. In later years, programs at the Hanford Site were diversified to include research and development for advanced reactors, renewable energy technologies, waste disposal technologies, and cleanup of contamination from past practices.

2.1.3 Mission

The new mission for Hanford emphasizes these components:

- Waste management of stored defense wastes and the handling, storage, and disposal of radioactive, hazardous, mixed, or sanitary wastes from current operations.

- Environmental restoration of approximately 1,500 inactive radioactive, hazardous, and mixed-waste sites and about 100 surplus facilities.

- Research and development in energy, health, safety, environmental sciences, molecular sciences, environmental restoration, and waste management.

- Technology development of new environmental restoration and waste management technologies, including site characterization and assessment methods; waste minimization, treatment, and remediation technology; and education outreach programs.

The DOE has set a goal of cleaning up Hanford's waste sites and bringing its facilities into compliance with local, state, and federal environmental laws by 2018.

2.1.4 Management

The Hanford Site is owned by the federal government and managed by the U.S. Department of Energy, Richland Operation's Office (DOE-RL). Westinghouse Hanford Company is the site operations and engineering contractor. Pacific Northwest Laboratory, which is operated for the DOE by Battelle Memorial Institute, manages the research and technology laboratories. In 1994, Bechtel Hanford Company and a team of contractors became DOE's environmental restoration contractor at the Hanford Site.

2.2 Regulatory Framework

The policy of DOE-RL is to carry out its operations in compliance with all applicable federal laws and regulations, state laws and regulations, presidential executive orders, and DOE orders. Environmental regulatory authority over the Hanford Site is vested both in federal agencies, primarily the U.S. Environmental Protection Agency (EPA), and in Washington State agencies, primarily the Department of Ecology. Significant environmental laws and regulations relevant to the management of SNF at Hanford are discussed in this section. First, major relevant federal and Washington State statutes are listed. Next, the specific topical concerns associated with spent nuclear fuel are discussed with appropriate citations to federal and state statutes and regulations. U.S. Department of Energy Orders will not be cited in this discussion because DOE Orders are not regulations. However, DOE Orders do delineate specific DOE procedures and provide detailed internal guidance for implementation of federal environmental, safety, and health regulations. DOE Orders establish specific standards, rules, and requirements that supplement the federal regulations for the design and construction of new facilities, and the operation of existing facilities to ensure safe and environmentally sound operations. Finally, it should be noted that environmental restoration and waste management activities at Hanford are governed by the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement), which includes detailed provisions for state and federal jurisdiction, as well as specific goals for site management and cleanup. The Fourth Amendment to the Tri-Party Agreement (January 1994) contains specific milestones (M-34) related to the management of SNF at the Hanford Site.

2.2.1 Significant Federal and State Laws

Significant federal and state environmental and nuclear materials management laws applicable to the Hanford Site include the following (grouped by federal and state and listed alphabetically):

Federal Laws

- American Antiquities Act (16 U.S.C. 431-433)
- American Indian Religious Freedom Act (42 U.S.C. 1996)
- Archaeological and Historic Preservation Act (16 U.S.C. 469-469c)
- Archaeological Resources Protection Act (16 U.S.C. 470aa-470ll)
- Atomic Energy Act (AEA) (42 U.S.C. 2011 et seq.)
- Bald and Golden Eagle Protection Act (16 U.S.C 668-668d)
- Clean Air Act (CAA) as amended by the Clean Air Act Amendments of 1990 (42 U.S.C. 7401

et seq.)

- Clean Water Act (CWA) (33 U.S.C. 1251 et seq.)
- Comprehensive Conservation Study of the Hanford Reach of the Columbia River (PL 100-605)
- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act (SARA) (42 U.S.C. 9601 et seq.)
- Emergency Planning and Community Right-to-Know Act of 1986 (42 U.S.C. 11001 et seq.)
- Endangered Species Act (16 U.S.C. 1531-1534)
- Energy Reorganization Act of 1974 (ERA) (42 USC 5801 et seq.)
- Federal Facilities Compliance Act (PL 102-386)
- Fish and Wildlife Coordination Act (16 U.S.C. 661-666c)
- Hazardous Materials Transportation Act (HMTA) (49 USC 1801 et seq.)
- Migratory Bird Treaty Act (16 U.S.C 703-711)
- National Environmental Policy Act (NEPA) (42 U.S.C. 4321 et seq.)
- National Historic Preservation Act (16 U.S.C. 470-470w-6)
- Native American Graves Protection and Repatriation Act (NAGPRA) (25 U.S.C. 3001 et seq.)
- Nuclear Waste Policy Act (NWPA) (42 U.S.C. 10101 et seq.)
- Pollution Prevention Act of 1990 (42 U.S.C. 13101 et seq.)
- Resource Conservation and Recovery Act (RCRA) as amended by the Hazardous and Solid Waste Amendments (42 U.S.C. 6901 et seq.)
- Safe Drinking Water Act (SDWA) (42 U.S.C. 300f et seq.)
- Toxic Substances Control Act (15 U.S.C. 2601 et seq.)
- Wild and Scenic Rivers Act (16 U.S.C. 1274 et seq.)

State Laws

- Washington Archaeological and Historic Preservation Code (RCW Chapter 27.34 et seq.)
- Washington Clean Air Act of 1967 (RCW Chapter 70.94 et seq.)
- Washington Hazardous Waste Management Act of 1976 (RCW Chapter 70.105 et seq.)
- Washington Model Toxics Control Act (RCW Chapter 70.105D).
- Washington Water Pollution Control Act (RCW 90.48 et seq.).

2.2.2 Environmental Standards for Spent Nuclear Fuel Storage Facilities

Design and performance standards for the construction and operation of SNF storage facilities arise from the Atomic Energy Act, Nuclear Waste Policy Act, Clean Water Act, and Clean Air Act, parallel state implementation statutes, and other major environmental/nuclear activities statutes. A general listing of regulations promulgated under these authorities will not be included in this discussion of the regulatory framework; relevant regulations will be cited as appropriate in the topical discussions that follow.

2.2.2.1 General Environmental Requirements for Construction and Operation.

Design and construction of new facilities, modification of existing facilities, and operation of all facilities would be conducted in accordance with applicable state and federal environmental regulations. Special consideration with respect to operations of SNF management facilities at Hanford are discussed in the following sections.

Columbia River water would be used to serve a wet SNF storage facility. The DOE has asserted that it has federally reserved water withdrawal rights with respect to its Hanford operations. Nevertheless, DOE submitted an application to the Washington State Department of Ecology on July 7, 1987, as a matter of comity for water withdrawal rights from the Columbia River for site characterization activities related to the now defunct Basalt Waste Isolation Project. It may be appropriate to maintain this protocol with Washington State in regard to future withdrawals from the river.

Operation of SNF facilities may involve the generation of waste materials or unintentional releases of waste materials to the environment. The Pollution Prevention Act requires prevention or reduction of waste at the source whenever feasible. Reporting and cleanup of spills from an SNF facility are governed by CERCLA regulations (40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan"), which apply to the release of hazardous substances into the environment, including radioactive substances.

Shipment of SNF is governed by Department of Transportation hazardous materials regulations in 49 CFR 171-179 (under the authority of the Hazardous Materials Transportation Act), which apply to the handling, packaging, labeling, and shipment of hazardous materials offsite, including radioactive materials and wastes. Safety standards for packaging and transporting radioactive materials are governed by U.S. Nuclear Regulatory Commission (NRC) standards established in 10 CFR Part 71, "Packaging of Radioactive Material for Transport and Transportation of Radioactive Material Under Certain Conditions."

2.2.2.2 Resource Conservation and Recovery Act. The status of SNF with respect to RCRA is discussed

in Volume 1. Most of the authority to administer the RCRA program, including treatment, storage and disposal standards, and permit requirements, has been delegated by EPA to the State of Washington, except for corrective action (cleanup). Washington State RCRA (WSHWMA) Dangerous Waste Regulations are found in WAC 173-303 (Washington Administrative Code). Generally, RCRA does not apply to source material, special nuclear material, by-product material, SNF, or radioactive-only wastes. Should SNF be processed into or commingled with a hazardous waste as defined by Subtitle C of RCRA, then the generation, treatment, storage, and disposal of the hazardous waste portion of such mixed waste would be subject to EPA regulations in 40 CFR 260-268 and 270-272.

2.2.2.3 Effluents. Regulations in 40 CFR 122 (and also in 40 CFR 125 and 129) apply to the dis-

charge of pollutants from any point source into waters of the United States. A National Pollutant Discharge Elimination System (NPDES) permit is required for such discharges, which would include any effluent discharge from an SNF storage facility into the Columbia River. The EPA has not yet delegated to the State of Washington the authority to issue NPDES permits at the Hanford Site. At 40 CFR 121 the regulations provide for state certification that any activity requiring a federal CWA water permit, i.e., an NPDES permit or a discharge of dredged or fill material permit, will not violate state water quality standards.

The EPA drinking water standards in 40 CFR 141, "National Primary Drinking Water Regulations," apply to Columbia River water at community water supply intakes downstream of the Hanford Site. Washington Administrative Code 173-200 sets water quality standards for groundwater, and WAC 173-201 establishes surface water quality standards for the State of Washington.

Department of Ecology regulations in WAC 173-216 establish a state permit program, com-

monly referred to as the 216 program, for the discharge of waste materials from industrial, commercial, and municipal operations into ground and surface waters of the state. Discharges covered by NPDES or WAC 173-218 (Underground Injection Control Program) permits are excluded from the 216 program.
The DOE has agreed to meet the requirements of the 216 program at the Hanford Site for discharges of liquids to the ground.

2.2.2.4 Air Quality. Hazardous emission standards in 40 CFR 61, "National Emission Standards for

Hazardous Air Pollutants," provide for the control of the emission of hazardous pollutants to the atmosphere, and standards in 40 CFR 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities," apply specifically to the emission of radionuclides from DOE facilities. Approval to construct a new facility or to modify an existing one may be required by these regulations. The EPA has not yet delegated this approval authority to the State of Washington for the Hanford Site.

The Clean Air Act Amendments of 1990 require the addition of 189 substances to the list of hazardous air pollutants to be regulated on a schedule that extends to 1999. The hazardous air pollutant list includes radionuclides. The amendments require the identification of source categories and the definition of required control technology (maximum available control technology) for each of these pollutants. Hanford may fall within the definition of a major source because total emissions from Hanford may exceed the triggering limit of 25 tons per year for any combination of listed hazardous air pollutants (emission standards using curies as the unit of measure for radionuclides will be promulgated in the future). This means that emission sources at Hanford may become subject to permitting and reporting requirements and to installation requirements (including retrofit) for control technology. A new SNF storage facility may be subject to the maximum available control technology requirements for new sources.

Washington State Department of Health regulations in WAC 246-247, "Monitoring and Enforcement of Air Quality and Emission Standards for Radionuclides," contain standards and permit requirements for the emission of radionuclides to the atmosphere from DOE facilities based on Department of Ecology standards in WAC 173-480, "Ambient Air Quality Standards and Emission Limits for Radionuclides."

The local air authority, Benton County Clean Air Authority, enforces General Regulation 80-7, which pertains to detrimental effects, fugitive dust, incineration products, odor, opacity, asbestos, and sulfur oxide emissions. Benton County Clean Air Authority has been delegated authority to enforce EPA asbestos regulations.

2.2.3 Protection of Public Health

Numerical standards for protection of the public from releases to the environment have been set by the EPA and appear in the Code of Federal Regulations. The most significant of the regulations are discussed in the following paragraphs.

Clean Air Act standards found in 40 CFR 61.92 apply to releases of radionuclides to the atmosphere from DOE facilities and state as follows:

> Emissions of radionuclides [other than radon-220 and radon-222] to the ambient air from Department of Energy facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 millirem/year.

Safe Drinking Water standards found in 40 CFR 141.16 apply indirectly to releases of radionuclides from DOE facilities to the extent that the releases impact community water systems:

> The average annual concentration of beta particle and photon radioactivity from man-made radionuclides in drinking water shall not produce an annual dose equivalent to the body or any internal organ greater than 4 millirem/year.

Also, maximum contaminant levels in community water systems of 5 pico- curies per liter of combined radium- 226 and radium-228, and maximum contaminant levels of 15 picocuries per liter of gross alpha particle activity, including radium-226 but excluding radon and uranium, are specified in 40 CFR 141. The tritium concentration that corresponds to a dose of 4 millirem per year is 20,000 picocuries per liter.

2.2.4 Species Protection

Regulations of the Endangered Species Act, the Bald and Golden Eagle Protection Act, and the Migratory Bird Treaty Act in 50 CFR 10-24, 222, 225-227, 402, and 450-453 apply to the Hanford Site. The Endangered Species Act requires a biological assessment to identify any threatened or endangered species likely to be affected by the proposed action.

2.2.5 Floodplains and Wetlands

Executive Order 11988, "Floodplain Management," Executive Order 11990, "Protection of Wetlands," and 10 CFR 1022, require an assessment of the effects of DOE actions on floodplains and wetlands. These requirements are directed at the protection of water quality and habitat.

2.2.6 Cultural and Historic Preservation

Requirements of the National Historic Preservation Act in 36 CFR 800, the American Antiquities Act in 25 CFR 261 and 43 CFR 3, and the Archaeological Resources Protection Act and the American Indian Religious Freedom Act in 43 CFR 7 apply to the protection of historic and cultural properties, including both existing properties and those discovered during excavation and construction. The American Indian Religious Freedom Act and the Native American Graves Protection and Repatriation Act also provide for certain rights of access by Native Americans to traditional areas of worship and religious significance.

2.3 Spent Nuclear Fuel Management Program

This section presents a summary of current plans, as of December 1994, for the management of existing SNF on the Hanford site. The following SNF and associated facilities are at Hanford (Bergsman 1994):

- N Reactor SNF- Zircaloy-clad metallic uranium fuel stored in water in the 105-KW and 105-KE basins and exposed to air in the Plutonium and Uranium Recovery through Extraction (PUREX) Plant dissolver cells A, B, and C.
- Single-pass reactor SNF - aluminum-clad metallic uranium fuel stored in water in the 105-KE and 105-KW basins and stored in water in the PUREX basin.
- Shippingport Core II SNF - Zircaloy-clad uranium dioxide fuel stored in water in T-Plant Canyon Pool Cell 4.
- Fast Flux Test Facility (FFTF) SNF - stainless steel-clad fuel stored in liquid sodium at the FFTF, consisting mostly of plutonium and uranium oxide fuel, but also uranium and/or plutonium metals, and carbide and nitride fuel.
- Miscellaneous commercial and experimental SNF - consisting mainly of Zircaloy-clad

uranium dioxide fuel stored in air in the 324, 325, and 327 buildings; TRIGA (training, research, and isotope reactors built by General Atomics) fuel stored in water in the 308 Building; miscellaneous fuel stored in air-filled shielded containers at the 200-West Area burial grounds; and aluminum-clad, uranium-aluminum alloy fuel stored in air in the Plutonium Finishing Plant.

Plans for management of Hanford SNF are included in the Hanford Spent Nuclear Fuel Project, Recommended Path Forward (Fulton 1994) and the Spent Nuclear Fuel Project Technical Baseline Document Fiscal Year 1995 (WHC 1995). It should be noted, however, that the SNF management program has continued to evolve since these documents were issued or drafted. Similarly, Hanford site-specific environmental documentation that will be required to support the Hanford SNF management program continues to evolve. Spent nuclear fuel EISs that are being prepared or that will be prepared include this programmatic EIS and a Hanford site- specific K Basins EIS. The programmatic EIS will lead to a record of decision that is scheduled to be published in June 1995. That record of decision will specify what SNF will be managed at which DOE sites, Naval Reactor Propulsion Program sites, or other sites. The K Basins EIS is expected to result in a record of decision that specifies where and how to relocate, stabilize, and safely store N Reactor and single-pass reactor SNF from the K Basins to address the urgent need to remedy safety and environmental vulnerabilities. The K Basins EIS record of decision will address management of this SNF over a 40-year period or until ultimate disposition.

During negotiations on the Fourth Amendment to the Tri-Party Agreement (TPA), the DOE, the State of Washington Department of Ecology, and the EPA agreed to an enforceable milestone that indirectly required issuing that record of decision by June 1996. The record of decision on the K Basins EIS would be dependent on the programmatic EIS record of decision. Other environmental documentation (EAs or EISs) will be prepared for any proposed actions related to SNF that are not specifically covered in the programmatic EIS or in the K Basins EIS.

Assuming the EISs are prepared as planned, the Hanford SNF management plan would identify and implement management approaches that will provide safe, cost-effective storage of SNF at existing facilities. Activities to identify, and then implement, the SNF management approach follow:

- Issuing the records of decision that are expected to result from the programmatic EIS and the K Basin EIS.
- Achieving accord with the TPA or renegotiating activities and milestones, as necessary.
- Providing facilities for SNF management as necessary to implement the EIS records of decision. SNF remaining onsite, as a result of the programmatic EIS record of decision could be placed in wet or dry storage in the 200-East Area until a decision on ultimate disposition has been made.
- Identifying and developing pathways for ultimate disposition of the SNF.
- Providing facilities and systems for preparing SNF for ultimate disposition.

  N Reactor and single-pass reactor SNF would be stabilized, as necessary, to implement the K Basins EIS record of decision. It is possible this stabilized form would be a metal or an oxide. Suitability of other SNF for ultimate disposition in its current form is yet to be demonstrated, but it is possible that FFTF and Shippingport SNF may not require further stabilization.

While the SNF management approach is being defined, the following key, near-term actions at the existing facilities are being implemented or are planned:

- Upgrading water treatment systems and retrieving sludges from the basins' floors.
- Performing necessary safety and security upgrades (e.g., water systems) to extend facility life until SNF removal can be accomplished.

- Transferring SNF from liquid-sodium storage at the FFTF to dry storage in interim storage casks. This activity would be integrated with FFTF deactivation.
- Transferring small quantities of SNF between existing facilities where deemed necessary to comply with other Hanford requirements.

Discussion of the SNF inventory and plans for managing that inventory are provided in the following sections. Planned SNF management activities are summarized in Table 2-1. Additional details on existing storage facilities are in Chapter 3.

2.3.1 N Reactor Spent Nuclear Fuel

N Reactor SNF is stored in three facilities (Bergsman 1994):

- 952 metric tons of uranium in 3815 closed canisters in the 105-KW Basin. The water in this basin has only low levels of radionuclide contamination.
- 1144 metric tons of uranium in 3666 open canisters in the 105-KE Basin. The water in this basin is contaminated with radionuclides, and there is a thick layer of sludge on the basin floor.
- 0.3 metric tons of uranium in the form of intact Mark IV fuel elements and fuel element pieces stored in air on the floor of PUREX dissolver cells A, B, and C.

Until recently, plans included 1) containerizing the fuel and sludge stored in the 105-KE Basin into Mark II (sealed) canisters; and 2) transferring the spent fuel in PUREX to the 105-KE Basin and containerizing it in the basin. Alternative approaches to each of these plans, including alternative containerization of fuel and sludge at the 105-KE Basin, expedited fuel removal from the K Basins and dry storage of fuel at PUREX, have been evaluated, and a path forward for these materials selected. PUREX SNF would be transferred to the K Basins and subsequently managed with the existing K Basins SNF inventory pending issuance of an environmental assessment. Expedited fuel removal from the K Basins has been selected in lieu of containerization because of benefits to worker safety and/or the environment. The 105-K Basins SNF would be relocated to a storage facility in the 200 Area, pending completion of the K Basins EIS. The impacts associated with implementation of this path forward are within the envelope of impacts analyzed in this EIS.

Table 2-1. Summary of planned spent nuclear fuel management activities.

In addition, work is ongoing to characterize the N Reactor and single-pass reactor fuel to provide data relevant to assuring continued safe storage and developing plans for future actions. Recent commitments to the Defense Nuclear Facilities Safety Board have set a date of December 1999 for completing removal of the SNF from the 105-K Basins.

Other N Reactor SNF, which may be recovered as a result of N Basin deactivation, would also be transferred to the 105-K Basins. A small quantity of this material (less than 0.5 MTHM) in the form of fuel fragments and chips is suspected to be in the sludge at the bottom of N Basin.

2.3.2 Single-Pass Reactor Spent Nuclear Fuel

The single-pass reactor SNF consists of residual fuel elements from the 105-KW and 105-KE reactors, plus residual elements from the clean-out of the 105-C and 105-D storage basins. Currently, 138 elements [0.4 metric tons of uranium (MTU)] are stored in the 105-KE Basin and 47 elements (0.1) are stored in the 105-KW Basin. In addition, four buckets filled with 779 single-pass reactor fuel elements are stored in the PUREX storage basin.

It was planned that the single-pass reactor fuel stored in PUREX would be transferred to the 105-KE

Basin, containerized, and possibly transferred to the 105-KW Basin before the previously planned Hanford SNF EIS record of decision would be issued. Activities to implement this action were initiated (Bergsman 1995). In parallel, alternative dry storage of this fuel was considered, consistent with the dry storage evaluation for N Reactor fuel at PUREX. To enable expeditious deactivation of the PUREX plant in support of the Hanford Site cleanup mission and because of the minimal impacts associated with relocation of this SNF to the 105-K Basins, shipment to the 105-K Basins was selected as the preferred approach for managing this SNF until issuance and implementation of the K Basins EIS record of decision. The SNF may be shipped directly to the 105-KW Basin instead of the 105-KE Basin and would be stored in a manner consistent with the requirements of the selected storage basin. The impacts associated with implementation of this path forward are within the envelope of impacts analyzed in this EIS.

2.3.3 Fast Flux Test Facility Spent Nuclear Fuel

The SNF from FFTF is stored in the following four FFTF locations, all of which use liquid sodium for cooling:

- the reactor core with a capacity of approximately(a) 82 fuel assemblies
- in-vessel storage with a capacity of 54 fuel assemblies
- interim decay storage with a capacity of 112 fuel assemblies and a limitation of 10 kilowatts per assembly
- the Fuel Storage Facility with a capacity of 380 fuel assemblies(b) and a limitation of 1.4 kilowatts per assembly.

The 1993 inventory of irradiated SNF at FFTF consists of fuel from 329 assemblies; an additional 55 non-irradiated driver fuel assemblies exist. Some irradiated fuel assemblies have been disassembled, with the fuel now placed in 40 Ident 69 containers or in the Interim Examination and Maintenance Cell. Some irradiated fuel has been shipped offsite, but is expected to be returned to Hanford.

The DOE plans to transfer FFTF spent nuclear fuel from the liquid sodium-cooled storage facilities into dry storage casks. These interim storage casks would hold six or seven assemblies per cask. Delivery of an initial ten casks has been scheduled for August 1995 and an environmental assessment for this activity has been submitted (Bergsman 1995). The majority of the casks would be sited in the 400 Area; however, a few may be sited at the Plutonium Finishing Plant because of requirements for additional physical security. A small fraction of the FFTF SNF is sodium bonded, and may be shipped directly offsite without emplacement in dry storage casks if the decision in this EIS is to relocate these materials to another DOE site.

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a. Capacity for each core-loading varies.
b. The Fuel Storage Facility actually has a capacity of 466 fuel assemblies, but is limited to only 380 because of criticality requirements.

2.3.4 Shippingport Core II Spent Nuclear Fuel

The Shippingport Core II spent nuclear fuel is stored in water in the 221-T Building (T-Plant) Canyon Pool Cell 4. The 72 standard blanket assemblies will remain in basin storage in T-Plant until site-specific NEPA review is completed to enable implementation of dry storage or transfer offsite. Site-specific NEPA review will not be initiated until issuance of the record of decision for this EIS. (One un-irradiated blanket assembly is also stored in air in the T-Plant.)

2.3.5 Miscellaneous Spent Nuclear Fuel

A variety of miscellaneous spent nuclear fuel is stored in the 300 Area, Plutonium Finishing Plant, and low-level burial grounds (Bergsman 1994). Specific actions that have been identified (Bergsman 1995) follow:

- The spent nuclear fuel stored in air in the 324, 325, and 327 buildings (mostly commercial, light-water reactor fuel, i.e., Zircaloy-clad uranium dioxide) is planned for relocation onsite; an environmental assessment for this activity will be prepared. The planned storage facility is a dry storage cask.
- TRIGA fuel stored in water in the 308 Building is planned for relocation onsite to the 400 Area so that the 308 Building can be deactivated; an environmental assessment has been submitted for this activity. Alternative disposition of the TRIGA fuel may be implemented; transfer of this fuel to the Idaho National Engineering Laboratory (INEL) is assumed in the INEL 1992/1993 Planning Basis Alternative.
- Miscellaneous fuel residues in the 200 Area are currently being managed as remote-handled transuranic waste. The TRIGA SNF at the burial grounds will be relocated onsite during burial grounds retrieval operations.

3. SPENT NUCLEAR FUEL MANAGEMENT ALTERNATIVES

3.1 Description of Alternatives

Five major alternatives are being evaluated for safely storing SNF until ultimate disposition is determined. These five alternatives are 1) No Action, 2) Decentralization (with a subset of local stabilization and storage options), 3) 1992/1993 Planning Basis, 4) Regionalization (with options A, B1, B2, and C), and 5) Centralization (minimum and maximum options). The five alternatives and their impacts are being evaluated concurrently by the sites or agencies potentially affected by these alternatives, including Hanford, Savannah River Site (SRS), Idaho National Engineering Laboratory (INEL), Oak Ridge National Laboratory (ORNL), the Nevada Test Site (NTS), and the Naval Nuclear Propulsion Program.

This chapter describes the spent fuel inventories, activities, and facilities anticipated at Hanford under the various storage alternatives. The inventory of SNF expected to be stored at Hanford under each alternative is summarized in Table 3-1. There are eight types of fuel listed in Table 3-1 to represent the wide variety of SNF currently held at various sites across the United States. In addition, the United States has obligations for some SNF held in foreign countries. The specific kinds of SNF held at Hanford that contribute toward the total SNF inventory are shown in parentheses in column one of Table 3-1. In terms of metric tons of heavy metal, Hanford has about 80 percent of DOE's current SNF inventory, primarily because of the large inventory of spent fuel remaining from the shut-down N Reactor. The Centralization Alternative minimum option is not shown in Table 3-1 because the inventory would eventually be zero at Hanford under this option, as it is in the Regionalization Alternative Option C. An overview of the SNF inventory as of the year 2035, planned activities, and existing and new facilities that may result under each of the five storage alternatives is provided below.

The No Action Alternative described in Subsection 3.1.1 forms the basis for comparison with the remaining four storage alternatives and includes descriptions of the expected activities, and existing storage facilities. Decentralization (Subsection 3.1.2), the 1992/93 Planning Basis (Subsection 3.1.3), Regionalization (Subsection 3.1.4), and Centralization (Subsection 3.1.5) are discussed in the remaining sections.

Table 3-1. Spent nuclear fuel inventory at Hanford under the various storage options as of 2035 in MTHM. ,b

Fuel type (name of Hanford SNF that is part of this type)	No Action and Decentralization	1992/1993 Planning Basis	Regionalization A[c]	Regionalization B1[d]	Regionalization B2[e]	Regionalization C[f] and Centralization minimum option	Centralization maximum option
Naval SNF	0.00	0.00	0.00	10.23	65.23	0.00	65.23
Savannah River and aluminum-clad	0.00	0.00	0.00	8.76	8.76	0.00	213.09
Hanford (N Reactor and single-pass reactors)	2103.17[g]	2103.17	2103.17	2103.17	2103.17	0.00	2103.17
Graphite	0.00	0.00	0.00	27.60	27.60	0.00	27.61
Commercial miscellaneous fuels	2.30	2.30	0.00	125.18	125.18	0.00	156.51
Experimental, stainless steel clad (FFTF)	11.27	11.23	0.00	90.12	90.12	0.00	96.51
Experimental, Zircaloy clad (Shippingport)	15.70	15.70	0.00	64.84	64.84	0.00	77.99
Experimental, other such as ceramic, liquid/salt, etc.	0.00	0.00	0.00	0.29	0.29	0.00	1.70
TOTALS:	2132.44	2132.40	2103.17	2430.19	2485.19	0.00	2741.80

a. MTHM - Metric tons of heavy metal (thorium, uranium, and plutonium as applicable).

b. Source: Wichmann (1995). Quantities of SNF within a given category may be the result of adding together several quantities, some large and some small, stored at different locations. Individual values are known to within about 1%. Additional digits are shown in the table as a check on calculations, but inventory totals are known to only two significant figures.

c. All Hanford production SNF remains at Hanford. All other SNF goes to INEL (including Hanford commercial, experimental stainless-steel-clad, and TRIGA).

d. All SNF currently located or to be generated in the U.S. west of the Mississippi River is sent to and stored at the Hanford Site, with the exception of Naval SNF.

e. All SNF currently located or to be generated in the U.S. west of the Mississippi River and all Naval SNF are sent to and stored at the Hanford Site.

f. All Hanford Site SNF and all other SNF currently located or to be generated in the U.S. west of the Mississippi River is sent to and stored at either INEL or NTS. For Hanford, this alternative is identical to the Centralization Alternative minimum option (SNF is shipped offsite).

g. This represents the post-irradiation (end-of-life) quantity. The pre-irradiation quantity, (2116.67 MTHM) is sometimes quoted.

3.1.1 No Action Alternative

Under the No Action Alternative, only those actions that are deemed necessary for continued safe and secure management of the SNF would be conducted. Thus, the existing SNF would be maintained close to its current storage locations, and there would be minimal facility upgrades. Activities required to store SNF safely would continue at each specific site (DOE 1993b).

A description of the anticipated activities that would be necessary under the No Action Alternative is provided in Subsection 3.1.1.1, followed by descriptions of existing facilities (Subsection 3.1.1.2), and any new facilities (Subsection 3.1.1.3). A comprehensive inventory and description of the fuel at Hanford as of January 1993 is given by Bergsman (1994). That report provides detailed information on many of the spent fuel designs and radionuclide inventories.

3.1.1.1 Anticipated Activities. In order to carry out the No Action

Alternative, the following activities would occur at the Hanford Site:

- Characterization of the defense production reactor fuel would proceed to establish the basis for safe storage.

- Fuel and sludge would be containerized at the 105-KE Basin or other onsite location.

- The first 10 dry storage casks would be procured for Fast Flux Test Facility (FFTF) fuel.

Consolidation of SNF from defense production reactors into the 105-KW Basin could occur. Other fuel may be transferred to dry cask storage where required for safety.

3.1.1.2 Description of Existing Facilities. SNF is presently located

in 11 facilities on the Hanford Site: 105-KE and 105-KW Basins at the north end of Hanford in the 100-K Area; T Plant, low-level waste burial grounds, and Plutonium Finishing Plant in the 200 West Area; Plutonium and Uranium Recovery through EXtraction (PUREX) plant in the 200 East Area; FFTF in the 400 Area; and 308, 324, 325, and 327 buildings in the 300 Area in the southeast corner of the site. Continued storage in these facilities is being evaluated because the No Action Alternative includes activities required to ensure safe and secure storage. The Plutonium Finishing Plant and PUREX facilities are excluded from this evaluation because SNF will not remain in those two facilities under any of the alternatives. For the purposes of this analysis, SNF at PUREX is assumed to be relocated to the K Basins.

Most of the facilities at the Hanford Site are decades old, some over 40 years, except for the FFTF and its associated storage buildings. A general description, the capacity for additional storage of SNF, and the means by which SNF can be received or removed from each facility are provided in Table 3-2. The dimensional information is for the actual storage area and not for the entire facility in order to provide a basic idea of the storage area required for that specific inventory of SNF. In many cases, such as the facilities in the 300 Area, only small portions of the actual facilities are used to store the spent fuel.

The K Basins contain the vast majority of the SNF at Hanford. The T-Plant, 308, 325, and 327 buildings, and the Plutonium Finishing Plant contain small amounts of stored SNF of various kinds. Four FFTF locations contain all the FFTF spent fuel, presently stored in sodium: the Reactor Core, In Vessel Storage, Interim Decay Storage, and Fuel Storage Facility (a building separate from the reactor containment building). The first of 60 new dry storage casks are expected to be available for FFTF fuel by late 1995. The existing facilities have very little additional capacity (see Table 3-2). While there is presently excess capacity in the K Basins, this is expected to be consumed by the planned operations, regardless of the storage alternative chosen.

The accessibility and limits on loading SNF are provided as key factors in movement of any fuel from these facilities to other locations on or offsite. Rail access is available at the facilities storing most of the fuel (K Basins, PUREX, and T Plant); truck shipments would be used for the rest. Acceptable casks and procedures for moving these casks may require evaluation in many cases. Additional details on these facilities are provided by Bergsman (1994), Bergsman (1995), and Monthey (1993).

The changes to the existing facilities that were analyzed under the No Action Alternative of SNF storage are shown in Table 3-3.

Table 3-2. Description of existing facilities (Bergsman 1994; Bergsman 1995).

Facility	Description	Capacity	Access
105-KE Basin	Water storage pool; 38 m x 20 m x 6 m deep; concrete walls and floor; no sealant or liner	75% full, 100% full after containerization	By rail 27 MT crane, fairly restrictive
105-KW Basin	Water storage pool; 38 m x 20 m x 6 m deep; concrete walls and floor; epoxy sealant; no liner	75% full[a]	By rail 27 MT crane, fairly restrictive
T Plant: Cell 4	Water storage pool; 4 m x 8.4 m x 5.8 m deep (water)	50% full	By rail or truck All fuel handling remote
PUREX Plant: East end of 202A Bldg. plus Dissolver Cells A, B, and C	Water storage pool; 9.5 m x 6.1 m x 5.2 m deep; Dissolver Cell sizes vary	No additional capacity	Shipment by rail 36 MT crane
Plutonium Finishing Plant: 2736-ZB Bldg.	Dry storage in 55 gal drum	No additional capacity	Shipment by truck
Fast Flux Test Facility: Reactor in-vessel storage, interim decay storage, and fuel storage facility storage locations	Liquid sodium pool storage (fuel storage facility is separate from reactor containment building, with limit of <1.4kW/assembly)	More than 75% full	By truck 91 MT Crane
200 Area LL Burial Grounds: 218-W-4C Trench 1 and 7; and 218-W-3A Trench 8 and S6	Dry, retrievable storage; 13 lead-lined, concrete-filled 208 liter drums, soil covered; 22 concrete casks (1.66 m x 1.66 m x 1.22 m or 1.92 m high), soil covered; 39 EBR II casks (1.5 m high x 0.4 m diameter), soil covered; 1 Zircaloy Hull Container (152 cm long x 76 cm diameter)	Large additional capacity	By truck
308 Building Annex: Neutron Radiography Facility	Built in late 1970's water storage pool; 2.8 m diameter x 6 m deep	Small additional capacity	Truck shipments 4.5 MT crane
324 Building: B and D Cells	Dry storage in air; B Cell: 6.7 m x 7.6 m x 9.3 m high (SNF uses <10% of floor space). D Cell: 4 x 6.4 m x 5.2 m high (small part for fuel), thick concrete walls and floors with steel liners	Small additional capacity	Truck shipments only B Cell - 2.7 and 5.4 MT cranes; Airlock - 27 MT crane
325 Building: A and B Cells in 325 Radiochemical Facility; 325 Shielded Analytical Laboratory	Dry storage in air 325A - 1.8 m x 2.1 m x 4.6 m high (typical cell) 325B - 1.7 m x 1.7 m floor area (typical cell)	Small additional capacity	Truck shipments only 325A - 27 MT crane 325B - 2.7 MT crane
327 Building: A - F and I Cells; Upper and Lower SERF; Dry Storage vault; EBR II cask; Large Basin	Dry storage in air, except for water in large basin; variety of cell sizes, but storage only for fuel research	Small additional capacity	No direct rail Truck shipments 13.5 and 18 MT cranes

a. If 105-KE Basin fuel is consolidated with 105-KW Basin fuel, 105-KE Basin would be shut down. The storage capacity of 105-KW Basin would be increased by replacing all the storage racks to allow multitiered stacking of fuel storage canisters and by making minor facility modifications.

Table 3-3. Assumed changes to existing Hanford facilities in the No Action

Alternative.

Facility	Facility changes
105-KE Basin	Fuel and sludge to be containerized; plans to upgrade safety and security systems
105-KW Basin	Fuel is already containerized; plans to upgrade safety and security systems
T Plant	None
PUREX Plant	Fuel to be moved to alternative location (assumed to be 105-K Basins for this alternative)
Plutonium Finishing Plant	None
Fast Flux Test Facility	None: Procure 10 dry storage casks by 8/95 (Bergsman 1995). Casks to weigh 50 T with storage cavity 3.8 m high x 0.56 m diameter (Bergsman 1994)
200 Area LL Waste Burial Grounds	None
308 Building Annex	None
324 Building	None
325 Building	None
327 Building	None

3.1.1.3 Description of New Facilities. No new buildings were analyzed

for the Hanford Site under the No Action Alternative. The only activities that were analyzed are those described for containerizing the N Reactor fuel and procuring casks for storage of FFTF fuel. The casks would be stored above ground on an existing concrete pad at the FFTF (Bergsman 1995). Major changes in rail, electrical, water, or other utilities are not expected under this alternative.

3.1.2 Decentralization Alternative

In the Decentralization Storage Alternative, as in the No Action Alternative, the current spent fuel inventory would continue to remain close to the point of generation or defueling. There are some existing storage sites that may receive or ship spent fuels, such as naval spent fuel, under one of several options under the Decentralization Alternative, but these options do not impact Hanford (DOE 1993a). No SNF would be shipped offsite or received from other storage locations outside of Hanford, but local transport might take place to support safety requirements and research and development. The Decentralization Alternative differs from the No Action Alternative in that significant facility development and upgrades are assumed, and spent fuel characterization, research and development, and possibly stabilization would occur. Summaries of the anticipated activities (Subsection 3.1.2.1) and facility requirements (Subsections 3.1.2.2 and 3.1.2.3) are provided below.

3.1.2.1 Anticipated Activities. The Decentralization Alternative would

include the three activities (fuel characterization, fuel and sludge containerization, and cask procurement for FFTF fuel) mentioned above in Subsection 3.1.1 for the No Action Alternative as well as the following general activities:

- Characterization of defense production fuels (N Reactor and single-pass reactor) to determine the feasibility of dry storage
- Evaluation of dry storage for other fuels (Shippingport Core II, FFTF, miscellaneous)
- Research and development on N Reactor fuel stabilization
- Construction and utilization of wet and/or dry storage facilities as well as a stabilization facility to support storage.

Only the defense fuels are being considered for wet storage, but dry storage in casks or vaults could be used for all or part of Hanford's spent fuel inventory under various options (Bergsman 1995). There are four basic options considered for storage of the spent fuels at Hanford under the Decentralization Alternative. Options W and X include both wet and dry storage: wet storage for defense fuels and dry storage for all other spent fuels in either a vault or casks. Options Y and Z involve only dry storage, again either in a vault or casks, but these options include one of three stabilization options for the metallic defense fuels.

The three potential processes considered for stabilizing the defense fuels in conjunction with Options Y and Z are shear/leach/calcine (P), shear/leach/solvent extraction (Q), and drying and passivation (D). Process P consists of shearing the fuel into a continuous dissolver and dissolving it in a nitric acid solution. Eventually, the processed material (without any radionuclide removal) is calcined, pressed into a ceramic waste form, and sealed in metal canisters.

Process Q uses solvent extraction by which metallic defense fuels are dissolved, separating uranium and plutonium and a liquid high-level waste stream that would most likely be vitrified for disposal in a geologic repository. In Process Q it is assumed that the process would be carried out on the Hanford Site. In commenting on the draft EIS, British Nuclear Fuels Limited (BNFL) proposed such processing be carried out in their facilities overseas. A discussion of the proposed sub-option is provided in Attachment B. Except for the additional impacts associated with transporting SNF from the Hanford Site to a West Coast shipping port, transoceanic shipment, transport of the SNF overland to BNFL facilities, and return shipment of resource materials (uranium-trioxide and plutonium-dioxide) and vitrified high-level waste, environmental impacts would be similar to those determined for Process Q.

Process D consists of drying and passivating the spent fuel and then canning it for storage. The relationships between the storage and stabilizing options are shown in Table 3-4.

Option W involves moving the N Reactor fuel from the existing basin storage into a new basin to be built by the year 2001. Simultaneously, a modular dry vault would be built for storage of the rest of the spent fuel at Hanford. Option X considers the use of casks for dry storage instead of the vault, but still requires moving the N Reactor fuel to a new basin. The casks would be placed on concrete pads outside of any buildings and would include two types of cask designs: concrete modules holding a storage cask, and upright concrete casks designed specifically for the FFTF fuel. Option Y would result in all of the non-defense spent fuel at Hanford being placed in a large vault facility. The defense fuel would require processing in a new facility by one of three options (P, Q, or D) prior to canning and placement in storage. The defense fuels processed using Option P or Option D would be stored in the vault; however, Option Q would result in several products that would be stored or processed further as high-level waste (Bergsman 1995). The final option, Option Z, is similar to Option Y except that casks would be used instead of a dry storage vault for all of the nondefense spent fuels. The defense fuels are handled as in Option Y. Additional details are provided by Bergsman (1995).

Table 3-4. Options under the Decentralization Alternative for Hanford.

Storage option	Stabilization option	Description	Facility requirements
W	None	Wet storage of defense fuels Dry storage of other fuels	New basin New vault
X	None	Wet storage of defense fuels Dry storage of other fuels	New basin New casks
Y	P, Q, or D	Dry storage of all fuel; stabilize defense fuels prior to storage	New vault; new processing facility [calcining (P), solvent extraction (Q), or drying and passivation (D)]
Z	P, Q, or D	Dry storage of all fuel; stabilize defense fuels prior to storage	New dry storage casks; new processing facility [calcining (P), solvent extraction (Q), or drying and passivation (D)]

3.1.2.2 Description of Existing Facilities and Impacts from the

Decentralization Alternative. The description of the existing facilities used to store SNF at Hanford was provided in Subsection 3.1.1.2. The Decentralization Alternative would impact the facilities beyond that already mentioned for the No Action Alternative to the extent that fuel would be removed from several of them: the Shippingport fuel would be removed from T

Plant to a designated interim storage location on site; FFTF fuel would continue to be removed from the sodium-cooled storage facilities and placed in dry storage casks; and fuel in the 200-W burial grounds might be relocated onsite.

As shown in Table 3-2, there is very little excess capacity in any of the facilities in which fuel is currently stored. The storage basins, in addition to being old, were built for temporary holding, for a matter of months only; hence, bringing them up to standards for prolonged storage would be fraught with problems and would not be cost-effective. Except for the burial grounds, the locations in which SNF is currently held in air were not intended for prolonged storage either, having been built for temporary holding for research and development or pre-processing. The FFTF storage facilities are all dependent on maintaining sodium in the liquid state as coolant and storage medium, which is not cost-effective for 40 years of storage for nonbeneficial use. Hence, the existing facilities are not considered for use in the 40 year storage scenario.

3.1.2.3 Description of New Facilities. A minimum of two new facilities

are required, regardless of which option is chosen for storing spent fuel under the Decentralization Alternative. Both Options W and X require a new basin and either a new vault or a new cask storage facility. Descriptions of these potential new facilities are provided in Table 3-5. A proposed site consisting of about 260 hectares (one-quarter section) for construction of all new facilities is located as shown in Figure 4-1. The cask facility would cover about twice as much land area as a vault facility and would involve modular systems placed outside on concrete pads. While the basin requirement is dropped for Options Y and Z, a process facility is needed for the metallic defense fuels in addition to the new dry storage facility. The specifics of this facility vary depending on whether they involve shear/leach/calcining (process P), shear/leach/solvent extraction (process Q), or drying and passivation (process D). For process Q, it is assumed that a vitrification plant and storage facilities will be available for the processed spent fuel that would then consist of three products. The vitrification plant and storage for high-level wastes are part of the overall plan for Hanford.

The potential processing facilities that will result from this alternative will require increased utilities, compared with the new dry storage facilities that are not expected to have major utility requirements. A rail system for receiving spent fuel at the various facilities may be required and could be tied into the existing system. Water requirements are expected to be insignificant. Estimates of the power requirements for processes P, Q, and D are 10 megawatts, 18 megawatts, and 3 megawatts, respectively. While the existing excess electrical capacity of 21 megawatts would be sufficient for one of these facilities, other potential uses of the existing electrical power capacity may require upgrading the existing power system (Bergsman 1995).

3.1.3 1992/1993 Planning Basis Alternative

The 1992/1993 Planning Basis Alternative defines those activities that were already scheduled at the various sites for the transportation, receipt, processing, and storage of SNF.

3.1.3.1 Description of Spent Fuel Inventory As in the previous two

alternatives, no new spent fuel would be received at Hanford under the 1992/1993 Planning Basis Alternative. However, the 101 spent fuel elements currently in the 308 Building from TRIGA reactors and the small amount of TRIGA fuel from Oregon State University currently in the 200-W Area burial grounds would be shipped to INEL.

Table 3-5. Description of required facilities under the Decentralization Alternative.

New facility	Description	Capacity
Water Basin (W, X)	Building: 110 m long x 42.7 m wide x 19.8 m high	2103 MTU in 8000 canisters

	Land use: <8094 m2 (<2 acres) Water storage pool: rectangular, 520 m2, cast-in-place concrete Canisters: double barreled, each 0.23 m diameter x 0.74 m high Construction: 3 year duration, operation by 2001	
Dry Storage Vault Facility (W)	Building: 39.6 m long x 48.8 m wide x 19.8 m high Land use: <4047 m2 (<1 acre) Modular vault: metal tubes vertically arrayed in cast-in-place concrete structure; inert cover gas; natural convection cooling. Canisters: short, 0.508 m diameter x 3.96 m (FFTF fuels); long, 0.559 m diameter x 4.57 m (other non-defense fuels) Construction: 3 year duration, operation by 2001	30 MTHM in 60 short and 25 long canisters
Dry Storage Cask Facility (X)	Building: none, concrete pads Land use: <8094 m2 (<2 acres) Cask Systems: 1) FFTF casks, 2.29 m diameter x 4.57 m high, 45.4 MT each, 2) Concrete module with fuel cask; reference storage module is 2.96 m wide x 5.52 m deep x 4.57 m high Canisters: 0.508 m diameter x 3.96 m (FFTF cask); 1.68 m diameter x 4.88 m long, weighs 90.8 MT (storage module) Construction: 3 year duration, operation by 2001	30 MTHM, 60 cask/ canisters (FFTF design) and 6 storage modules/ casks
Shear/Leach / Calcine Process or Z Facility (Y)	Building: multilevel, steel-reinforced, cast in place concrete; 110.3 m long x 55.2 m wide x 25.9 m high (15.8 m above grade); shielded main canyon is 6.1 m wide x 70.1 m long x 25.9 m high; Land Use: 6070 m2 (1.5 acres) Operation: 24 hours/day, 7 days/week for 4 years to stabilize defense fuels; 75% efficiency; 280 day/year Construction: 3 year duration, operation by 2001	2103 MTU in 4 years 2.5 MTU/day
Dry Storage Vault Facility (Y)	Building: 100.6 m long x 88.4 m wide x 18.3 m high Land use: <8094 m2 (<2 acre) Modular vault: metal tubes vertically arrayed in cast-in-place concrete structure; inert storage atmosphere; natural convection cooling. Canisters: 0.559 m diameter x 4.11 m (defense fuels); short, 0.508 m diameter x 3.96 m (FFTF fuels); long, 0.559 m diameter x 4.57 m (other non-defense fuels) Construction: 3 year duration, operation by 2001	2133 MTHM in ~1200 defense canisters, 60 short and 25 long non-defense canisters
Dry Storage Cask Facility (Z)	Same as Dry Cask Storage Facility described for Option X Land use: 20,234 m2 (5 acres) Canisters: add storage modules/casks for stabilized defense fuels; same storage container dimensions as for Option X	2133 MTHM in 60 cask/ canisters (FFTF), 230 modules/ casks (defense), and 6 modules/ casks (other non-defense)
Solvent Extraction Fuel Process Facility (Y or Z)	Building: multilevel, steel-reinforced, cast in place concrete; 26.5 m long x 77.7 m wide x 25.9 m high (15.8 m above grade); shielded main canyon is 6.1 m wide x 76.2 m long x 25.9 m high; Land Use: 6070 m2 (1.5 acres) Canisters: generates 2 kg/MTU of fuel processed, resulting in about 30 cans of glass for 2103 MTU of fuel Operation: 24 hours/day, 7 days/week for 4 years to stabilize defense fuels; 75% efficiency; 280 day/year Construction: 3 year duration, operation by 2001	2103 MTU in 4 years 2.5 MTU/day
Fuel Drying	Building: multilevel, steel-reinforced, cast	2103 MTU in 4

and Passivation Facility (Y or Z)	in place concrete; 115.8 m long x 64.0 m wide x 25.9 m high (15.8 m above grade); shielded main canyon is 6.1 m wide x 54.9 m long x 25.9 m high; Land Use: 6070 m2 (1.5 acres) Operation: 24 hours/day, 7 days/week for 4 years to stabilize defense fuels; 75% efficiency; 280 day/year Construction: 3 year duration, operation by 2000	years, 2.5 MTU/day

a. Source: Bergsman (1995).

3.1.3.2 Anticipated Activities Most of the activities previously

discussed for the decentralization storage alternative were already planned prior to this review. It was expected that all newly generated SNF that was owned by the U.S. Government would be sent to either INEL or to SRS. No new spent fuel was expected to be shipped to Hanford other than possibly limited quantities of material for research or other scientific endeavors supporting the nuclear industry. Upgrades and replacements of existing storage capacity were already planned and would involve those facilities described in Subsection 3.1.2 for the Decentralization Alternative. Thus, the activities that would be conducted under the 1992/1993 Planning Basis are the same as for the Decentralization Alternative under the four options listed in Table 3-4, except for the additional activity of shipping TRIGA spent fuel to INEL.

3.1.3.3 Description of Existing Facilities and Changes Required by

Alternative The description provided in Subsection 3.1.1.2 on the existing facilities for storing SNF at Hanford also applies to this alternative. No additional changes to facilities are anticipated from the 1992/1993 Planning Basis except that the 308 Building and the 200W Area burial grounds would no longer contain TRIGA spent fuel.

3.1.3.4 Description of New Facilities. The facilities that would be

required under the 1992/1993 Planning Basis are the same as those shown previously in Table 3-5 for the Decentralization Alternative. The impact on existing utilities would be the same as for the Decentralization Alternative, namely from 3 to 18 megawatts of power for stabilization facilities and minimal other impacts.

3.1.4 Regionalization Alternative

This alternative provides for the redistribution of SNF to candidate sites based on similarity of fuel types (Option A) or on geographic location (Options B1, B2, and C), in order to optimize the storage of SNF owned by the U.S. Government.

The Regionalization Alternative as it applies to the Hanford Site consists of the following options:

- Option A (regionalized by fuel type) - Defense production SNF would remain at Hanford; other types of SNF would be sent to INEL.
- Option B1 (geographic regionalization) - All SNF west of the Mississippi River except Naval SNF would be sent to Hanford.
- Option B2 (geographic regionalization) - All SNF west of the Mississippi River and Naval SNF would be sent to Hanford.
- Option C (geographic regionalization) - All Hanford SNF would be sent to INEL or NTS.

Facilities and features of Regionalization Option A would be the same as those described for Hanford defense production fuel in the Decentralization

Alternative. The facilities and features for all other Hanford SNF would be very similar to those described for that SNF in the Centralization Alternative minimum option.

Facilities and features of Regionalization Options B1 and B2 would be incremental to those described for the Decentralization Alternative and would include facilities and features similar to those described in the Centralization Alternative maximum option.

Facilities and features of Regionalization Option C would be equivalent to those described for the Centralization Alternative minimum option.

3.1.4.1 Description of Spent Fuel Inventory. The spent fuel inventory

that would be stabilized and/or stored for each of the Regionalization options is shown in Table 3-1.

3.1.4.2 Activities Required by Each Option.

Option A, Suboption X

- wet storage of N Reactor and single-pass reactor fuel
- shipment of other Hanford Site fuel to INEL
- use of existing facilities (FFTF and T Plant) and new wet pool facilities to load shipping casks.

For N Reactor and single-pass reactor fuel, this option is the same as the Decentralization Alternative; for all other Hanford Site fuel, this option is nearly the same as for the Centralization Alternative minimum option.

Option A, Suboption Y

- dry storage of all defense production fuel in a large vault facility
- transport of other Hanford Site fuel to INEL
- defense production fuel stabilized prior to storage
- use of existing facilities (FFTF and T Plant) and a stabilization facility to load shipping casks
- leakers, if any, unloaded in a special module at a stabilization facility.

For N Reactor and single-pass reactor fuel, this option is identical to the Decentralization Alternative; for other Hanford Site fuel, this option is nearly identical to the Centralization Alternative minimum option.

Option A, Suboption Z

- dry storage of all fuel in casks in a large facility
- defense production fuel stabilized prior to storage
- dry storage casks loaded at existing facilities (FFTF and T Plant)
- use of existing facilities (FFTF and T Plant) and a stabilization facility to load shipping casks
- leakers unloaded in a special module at a stabilization facility.

For N Reactor and single-pass reactor fuel, this option is identical to the Decentralization Alternative; for other Hanford Site fuel, this option is nearly identical to the Centralization Alternative minimum option.

Option B1

All fuel from offsite would be stored dry in casks in a large facility, although a very small amount might require wet storage for an interim period prior to dry storage. SNF received from other DOE locations would arrive stabilized and canned as necessary for storage. SNF received from universities and SNF of U.S. origin from foreign research locations would require canning prior to storage. The required receiving and canning would be done in a new facility because of the extended period over which the fuel would be received. A small amount of fuel would arrive after only limited time since reactor discharge, which would require temporary water storage until it aged sufficiently to be dry stored. That water storage would be included in the receiving and canning facility. Technology development would be conducted in a separate, nearby facility.

Option B2

The activities for this option would be the same as those for Option B1, except that additional storage would be required for Naval fuel.

Option C

Hanford fuel would be stabilized as necessary, loaded, and shipped offsite.

3.1.4.3 Existing Facilities. Upgrades, replacements, and additions to

the existing facilities would occur as required under the Decentralization Alternative.

3.1.4.4 New Facilities. Research and development and pilot programs

for characterization, stabilization, and other needs to support future decisions on the ultimate disposition of SNF would also occur. Refer to Table 3-6 for the potential facility requirements under the three storage and three stabilization options. A description of these options is given in Section 3.1.2.1, Anticipated Activities under the Decentralization Alternative. Options X, Y, and Z with their respective stabilization suboptions are the same as those for the Regionalization and Decentralization Alternatives (see **Table 3-4).** What is different is the specific assortment of fuel to be managed in each of the alternatives. The stabilization facilities required under the Regionalization Alternative are the same as those listed in Table 3-5.

Table 3-6. Description of required facilities under Regionalization Alternatives.

Alternatives	New Facility	Description	Capacity
Regionalization A/ Suboption X RAX	Water basin	Building: 109.7 m long x 42.7 m wide x 12.2 m high pre-cast concrete Land use: <8094 m2 (<2 acres) Water storage pool: rectangular, 520 m2, cast-in-place concrete Canisters: double barreled, each 0.23 m diameter x 0.74 m high Construction: 3-year deviation, operation starting in 2001	~2103 MTU in 8000 canisters
Regionalization A/ Suboption Y RAY	Shear/leach/calcine stabilization process	See Table 3-5	
Regionalization A/ Suboption RAY	Large modular dry storage vault	Building: 94.5 m long x 88.4 m wide x 18.3 m high cast-in-place concrete, pre-cast concrete superstructure Land Use: ~8094 m2 (~2 acres) Canisters: 0.58 m diameter x 4.11 m high Construction: 3-year duration, operation to start in 2001	~2103 MTU in 1200 canisters
Regionalization A\ Suboption RAZ	Shear/leach/calcine stabilization process	See Table 3-5	
Regionalization A/	Concrete storage module	Building: 3.0 m wide x 5.5 m long x 4.6 m high Land Use: 16,187 m2 (4 acres)	2013 MTU in

Suboption RAZ prefabricated dry storage module casks	holding NUHOMSa casks	Casks: 1.7 m diameter x 4.9 m long Construction: 3 year duration, operation to begin in 2001	230

Table 3-6. (contd)

Alternatives	New Facility	Description	Capacity
Note: Facilities required for Alternatives RB1 and RB2 are in addition to those required for Decentralization			
Regionalization B1, RB1	Incremental cask storage	Building: 121.9 m x 365.8 m Similar to but larger than that for Decentralization Option X	330 MTHM 188 shipping casks, 50 storage casks
	Receiving and canning facility	Building: 53.3 long x 53.3 m wide x 16.8 m high 3 foot thick cast-in-place concrete	
	Technology development facility	Building: 53.3 m long x 30.5 m wide x 16.8 m high pre-cast concrete Land use for all three RB1 facilities: 40,469 m2 (10 acres) Construction: Receiving/canning and tech. dev. 1998-2001; for 90% of storage facility 2000-2010; for remaining 10% storage 2010-2035; operating period: 2000 through 2035	
Regionalization B2, RB2	Prefabricated by storage cask facility	Building: 914.4 m x 121.9 m; similar to but larger than Option X for Decentralization	400 MTHM (for total, with Decentralization, of 2500 MTHM) 188 shipping casks 50 storage casks
	Receiving and canning facility	Sames as for RB1	
	Technology development facility Land use for all three RB2 facilities: 101,172 m2 (25 acres)	Same as for RB1	

a. NUHOMs casks [Nutech Horizontal Modular Storage (from Pacific Nuclear)]

3.1.5 Centralization Alternative

Under the Centralization Alternative for SNF storage, all current and future SNF from DOE and the Naval Nuclear Propulsion Program would be sent to one DOE site or other location. The activities at each site would depend on whether the SNF was being received or shipped offsite. Sites not selected would close down their storage facilities once the fuel had been removed. The following information summarizes the expected impact at Hanford and provides insight into the characteristics of the SNF and facilities that would be involved in shipping these fuels to

Hanford.

3.1.5.1 Description of Spent Nuclear Fuel Inventory The SNF inventory

that would exist at Hanford under this alternative would include that which is presently at Hanford (see Table 3-1), as well as any new fuel shipped to Hanford. If the minimum option occurs under the Centralization Alternative, then all of this spent fuel would be shipped offsite and there would no longer be a spent fuel inventory at Hanford, barring any required for research. If the maximum option occurs, the spent fuel at all of the other sites across the United States would eventually be transported to Hanford.

The locations from which spent fuel would be sent, in addition to SRS and INEL, include Argonne National Laboratories East and West, Babcock and Wilcox, Brookhaven National Laboratory, General Atomics, Los Alamos National Laboratory, Oak Ridge National Laboratory, Sandia National Laboratories, West Valley, and Fort St. Vrain. Naval spent nuclear fuel from shipyards and prototypes would be sent first to the equivalent of the Expended Core Facility, which would be relocated to Hanford. There the fuel would be examined by the Naval Nuclear Propulsion Program prior to being turned over to DOE for storage at Hanford. Foreign fuel that may be returned to the United States following irradiation or testing offsite would also be included in this inventory under the Centralization Alternative. Summaries of the spent fuel at each site are shown in Volume I, Attachments B, C, and D and Volume III of DOE (1993a). Additional information is in DOE (1992a) (Fort St. Vrain and Peach Bottom high-temperature gas-cooled reactor spent graphite fuel).

3.1.5.2 Anticipated Activities. If Hanford is chosen as the site for

storing the entire spent fuel inventory, the upgrades, increases, and replacements of storage capacity would occur as required for the existing spent fuel as well as to accommodate the increased spent fuel inventory. If the Centralization Alternative is chosen and Hanford is not selected, the activities would include stabilization to ensure safe storage and transportation offsite.

All fuel received from offsite would be stored dry in casks in a large facility, although some may require wet storage for an interim period prior to dry storage. SNF received from other DOE sites will arrive stabilized and canned as necessary for storage. SNF received from universities and from foreign locations would require containerization prior to storage. Naval SNF would arrive uncontainerized, but would not require containerization. The required receiving and containerizing would be done in a new facility because of the large throughput involved and the extended period (40 years instead of 4) during which the fuel would be received. Some university and foreign fuel would require temporary wet storage. That water storage is included in the receiving and canning facility. Technology development would be conducted in a separate, nearby facility.

3.1.5.3 Description of New Facilities. The new facilities required for

the alternative in which all U.S. DOE SNF would be stored at the Hanford Site are of the same type as, but larger than, those required for Regionalization Alternative Option B2:

- The Prefabricated Dry Storage Cask Facility for offsite SNF would be approximately 120 meters x 1200 meters.
- The Receiving and Canning Facility would be approximately 110 meters x 50 meters x 20 meters high.
- The Technology Development Facility would be approximately 50 meters x 40 meters x 20 meters high.
- The land required for these three facilities together would be approximately 14 hectares (35 acres).

3.2 Comparison of Alternatives

A summary of environmental impacts among the various alternatives is provided in **Table 3-7.** The alternatives are briefly described below to aid in interpreting the material presented.

The No Action Alternative identifies the minimum actions deemed necessary for continued safe and secure storage of SNF at the Hanford Site. Upgrade of the existing facilities would not occur other than as required to ensure safety and security.

The Decentralization Alternative includes additional facility upgrades over those considered in the No Action Alternative, specifically, new wet storage (for defense production fuel only) or dry storage facilities, fuel processing via shear/leach/calcination or shear/leach/solvent extraction, with research and development activities to support such processing.

The 1992/93 Planning Basis Alternative differs from the Decentralization Alternative only in that TRIGA fuel currently stored at the Hanford Site would be shipped offsite. The storage and stabilization options identified for the Decentralization Alternative are also assumed for the 1992/1993 Planning Basis Alternative.

The Regionalization Alternative as it applies to the Hanford Site consists of the following options:

- Option A (fuel type) - Defense production SNF would remain at Hanford; other types of fuel would be sent to INEL.
- Option B1 (geographic) - All SNF west of the Mississippi River, except Naval SNF would be sent to Hanford.
- Option B2 (geographic) - All SNF west of the Mississippi River and Naval SNF would be sent to Hanford.
- Option C (geographic) - All Hanford SNF would be sent to INEL or NTS.

Table 3-7. Summarized comparisons of the alternatives[a].

Resource or Consequence	Alternatives							
	No Action	Decentralization	1992/1993 Planning Basis	Regionalization A	Regionalization B1	Regionalization B2	Centralization at Hanford	Regionalization C and Centralization Elsewhere
Traffic and transportation	No change in onsite traffic patterns. Total population dose would be less than one person-rem and no fatal cancers would be projected.	From 1 to 6 percent increase in onsite traffic depending on suboption selected. Total population dose would be less than 2 person-rem and no fatal cancers would be projected.		From 1 to 5% increase in onsite traffic depending on suboption selected. Total population dose less than 1 person-rem and no	Essentially same as Decentralization Alternative	Essentially same as Decentralization Alternative.	Essentially same as Decentralization Alternative.	Onsite traffic not significantly different from No Action Alternative. Essentially no change. Total population dose would be about 4

```
                                                                                              fatal
person-rem
                                                                                              cancers
and no fatal
                                                                                              would be
cancers would
                                                                                              projected.
be projected.
Health &
Safety (fatal
cancers over
40 years of
normal
operations)
Occupational  None (0.4)     None (0.04-                 None (0.04-   None (0.04-  None (0.3-
None (0.3-      None       None (0.08)
Public (max)  None (5.2 x     0.1)                       0.1)          0.1)         0.4)
0.4)            (0.4)      None (2.5 x
              10-4)          None (2.5 x                 None (2.5 x   None (2.5 x  None (2.5 x
None (2.5       None (2.5  10-3)
                              10-3)                      10-3)         10-3)        10-3)         x
10-3)         x 10-3)
Utilities and
energy        12,000         100-127,000                100-127,000   100-127,000  100-127,000
100-            100-       0-20,000
(megawatt-
127,000         127,000
hrs/yr)
electricalb
Materials and
waste
management
LLW, m3/y     95             41-420                      41-420        61-420       43-430
43-430          110-490    140-420
TRU waste,    0              0-50                        0-50          0-50         0-50
0-50            0-50       0-50
m3/y
HLW, m3/y     0              0-57                        0-57          0-57         0-57
0-57            0-57       0-57
Mixed waste,  1              0.23-2.10                   0.23-2.0      0.23-2.0     0.26-2.0
0.26-2.0        0.51-2.3   1.0-2.0
m3/y
Hazardous     2.3            1.1-2.8                     1.1-2.8       1.1-2.8      1.2-2.9
1.2-2.9         2.3-3.9    1.4-2.8
Waste, m3/y
```

a. Hyphenated numbers indicate range of values depending on processing options selected.

b. Minimum value represents requirements during the period after all fuel has been placed into dry storage or has been shipped offsite. Maximum value represents requirements during the interim period (less than 4 years) while SNF is being processed and prepared for storage or shipment offsite, assuming concurrent operation of the process facility and the existing facilities where SNF is currently stored (as in the No Action Alternative).

c. Spent filters and ion exchange resins are the only sources of TRU waste. Filters and resins are charged before they become TRU waste.

Table 3-7. (contd)

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Resource or          Alternatives
Consequence
                     No Action      Decentrali- 1992/1993     Regionali-  Regionali-
Regionali-      Centrali-    Regionali-
                                    zation      Planning      zation A    zation B1     zation B2
zation at    zation C
                                                Basis
Hanford      and

Centrali-

zation

Elsewhere
Postulated
Accidents

Facilities
Point estimate of    <3.7 x 10-     4.9 x 10-4  4.9 x 10-4    4.9 x 10-4  5.7 x 10-4    5.7 x
10-4      6.5 x 10-4   4.1 x 10-4
```

fatal cancer risk - worst consequences accident - public	3							
Workers	<1.4 x 10-7	5.6 x 10-7	5.6 x 10-7	5.6 x 10-7	6.6 x 10-7	6.6 x 10-7	7.5 x 10-7	4.7 x 10-7
Transportation								
Numbers of fatal cancers	None (5.5 x 10-2)	1(0.7)	1(0.7)	None (6.8 x 10-2)	1(0.7)	1(0.7)	1(0.7)	1(0.7)
Land use (area converted for SNF stabilization, packaging and/or storage)	No change	4 to 7 ha (11-18 acres)	4 to 7 ha (11-18 acres)	4 to 7 ha (11-18 acres)	15-17 ha (36-43 acres)	25-28 ha (61-68 acres)	35-38 ha (86-93 acres)	2 to 5 ha (6-12 acres)
Socioeconomics (worker-years over 10 years)	No change	798-6374	798-6374	618-4684	1716-7592	2088-8039	2857-9019	3905-5846
Cultural Resources	No change	No effects expected	No effects expected	No effects expected	No effects expected	No effects expected	No effects expected	No effects expected
Aesthetic and scenic	No change	No effects expected	No effects expected	No effects expected	No effects expected	No effects expected	No effects expected	No effects expected
Geologic resources	No change	No effects expected	No effects expected	No effects expected	No effects expected	No effects expected	No effects expected	No effects expected
Air quality and related consequences (fatal cancers over 40 years normal operations)	No change	None	None	None	None	None	None	None
Water quality and related consequences	Maximum radiological and nonradiological carcinogenic risks less than one chance per billion	Maximum radiological and nonradiological carcinogenic risks less than 50 chances per billion						No effects expected
Ecological resources (Habitat area destroyed)	No change	4 to 7 ha (11-18 acres)	4 to 7 ha (11-19 acres)	4 to 7 ha (11-18 acres)	15 to 17 ha (36-43 acres)	25-28 ha (61-68 acres)	35-38 ha (86-93 acres)	2 to 7 ha (6-12 acres)
Noise	No change	No effects expected	No effects expected	No effects expected	No effects expected	No effects expected	No effects expected	No effects expected

Two options exist at the Hanford Site for the Centralization Alternative: 1) the minimum option, in which all SNF on the Hanford Site would be shipped offsite, and 2) the maximum option, in which all SNF within the DOE complex would be shipped to the Hanford Site for management and storage. In the latter case, dry storage of all fuel sent to the Hanford Site from offsite would be assumed. A facility equivalent to the Decentralization suboptions would be assumed for stabilization of defense production fuel prior to storage; fuel received from offsite would have been stabilized for dry storage prior to receipt.

4. AFFECTED ENVIRONMENT

4.1 Overview

The Hanford Site is characterized by a shrub-steppe climate with large sagebrush dominating the vegetative plant community. Jack rabbits, mice, badgers, deer, elk, hawks, owls, and many other animals inhabit the Hanford Site. The nearby Columbia River supports one of the last remaining spawning areas for Chinook salmon and hosts a variety of other aquatic life. The climate is dry with hot summers and usually mild winters. Severe weather is rare. With construction of dams along the Columbia River, flooding is nearly nonexistent.

The Hanford Site was a major contributor to national defense during World War II and the Cold War era. The site was selected because it was sparsely settled and the Columbia River provided an abundant supply of cold, clean water to cool the reactors. As a result of wastes generated by these national defense activities, there are presently more than 1500 waste management units and four major groundwater contamination plumes. These have been grouped into 78 operable units: 22 in the 100 Area (reactor area), 43 in the 200 Area (chemical processing and refining areas), 5 in the 300 Area (research and development area), and 4 in the 1100 Area (storage area). An additional four units are found in the 600 Area (the rest of the Hanford Site). Each of these operable units is following a schedule for clean-up established by the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement), which involves the U.S. Department of Energy (DOE), the Washington Department of Ecology, and the EPA.

4.2 Land Use

A brief description of the existing land use on the Hanford Site and adjacent lands and a brief discussion devoted to the existing land use on the proposed project site area follow.

4.2.1 Land Use at the Hanford Site

The Hanford Site is used primarily by DOE. Public access is limited to travel on the two access roads as far as the Wye Barricade, on Highway 240, and on the Columbia River (see Figure 4-1). The site encompasses 1450 square kilometers (560 square miles), of which most is

Figure 4-1. Hanford Site showing proposed spent nuclear fuel facility location.

open vacant land with widely scattered facilities, old reactors, and processing plants (Figure 4-1). In the past, DOE has stated that it intends to maintain active institutional control of the Hanford Site in perpetuity (DOE 1989). In the future, DOE could release or declare excess portions of the Hanford Site not required for DOE activities. Alternatively, Congress could act to change the management or ownership of the Hanford Site. The DOE operational areas are described below:

- The 100 Area [11 square kilometers (4.2 square miles)], which borders the right bank (south shore) of the Columbia River, is the site of eight retired plutonium production reactors and N Reactor, which is in shutdown deactivation status.

- The 200-West and 200-East Areas [16 square kilometers (6.2 square miles)] are located on a plateau about 8 and 11 kilometers (5 and 7 miles), respectively, from the Columbia River. These areas have been dedicated for some time to fuel reprocessing and waste processing management and disposal activities. The proposed project would be located between these areas.

- The 300 Area [1.5 square kilometers (0.6 square miles)], located just north of the city of Richland, is the site of nuclear research and development.
- The 400 Area [0.6 square kilometers (0.25 square miles)] is about 8 kilometers (5 miles) north of the 300 Area and is the site of the Fast Flux Test Facility (FFTF) used in the testing of breeder reactor systems. Also included in this area is the Fuels and Material Examination Facility.
- The 600 Area comprises the remainder of the Hanford Site and includes the Arid Land Ecology Reserve (ALE) [310 square kilometers (120 square miles)], which has been set aside for ecological studies, and the following facilities and sites:
  - a commercial low-level radioactive waste disposal site [4 square kilometers (1.7 square miles)], part of which is leased by the State of Washington.
  - Washington Public Power Supply System nuclear power plants [4.4 square kilometers (1.7 square miles)].
  - a 2.6-square kilometer (1 square mile) parcel of land transferred to Washington State as a potential site for the disposal of nonradioactive hazardous wastes.
  - a wildlife refuge of about 130 square kilometers (50 square miles) under revocable use permit to the U.S. Fish and Wildlife Service.
  - an area of about 6 square kilometers (2.3 square miles) has been provided to site a National Science Foundation Laser Gravitational-Wave Interferometer Observatory west of the 400 Area. When completed, this facility will occupy about 0.6 square kilometers (0.2 square miles).
  - a recreational game management area of about 225 square kilometers (87 square miles) under revocable use permit to the Washington State Department of Game.
  - support facilities for the controlled access areas.

In addition, an area comprising 310 square kilometers (120 square miles) has been designated for use as the ALE by the U.S. Fish and Wildlife Service for a wildlife refuge and by the Washington State Department of Wildlife for a game management area (DOE 1986a). The entire Hanford Site has been designated a National Environmental Research Park.

The Columbia River adjacent to the Hanford Site is a major site for public use by boaters, water skiers, fishermen, and hunters of upland game birds and migratory waterfowl. Some land access along the shore and on certain islands is available for public use.

4.2.2 Land Use in the Vicinity of the Hanford Site

Land use adjacent to the Hanford Site to the southeast and generally along the Columbia River includes residential, commercial, and industrial development. The cities of Richland, Kennewick, and Pasco are located along the Columbia River and are the closest major urban land uses adjacent to the Hanford Site. These cities (known as the Tri-Cities) together support a population of approximately 96,000.

Irrigated orchards and produce crops, dry-land farming, and grazing are also important land uses adjacent to the Hanford Site. In 1985 wheat represented the largest single crop in terms of area planted in Benton and Franklin counties with 190 square kilometers (73 square miles). Corn, alfalfa, hay, barley, and grapes are other major crops in Benton and Franklin counties. In 1986 the Columbia Basin Project, a major irrigation project to the north of the Tri-Cities, produced gross crop returns of $343 million, representing 19 percent of all crops grown in Washington State. In 1986 the average gross crop value per irrigated acre was $664.00. The largest percent age of irrigated acres produced alfalfa hay, 29.4 percent of irrigated acres; wheat, 15.0 percent; and corn (feed grain), 9.4 percent. Other significant crops are potatoes, apples, dried beans, asparagus, and pea seed.

4.2.3 Potential Project Land Use

The potential project site (Centralization Alternative) is located between the 200-West and 200-East Areas. The land is currently vacant. The proposed project would consist of constructing an SNF facility on the site. This potential project would involve typical land uses that occur during construction phases and a more industrial/commercial land use after reaching the operational stage.

4.2.4 Native American Treaty Rights

In prehistoric and early historic times, the Hanford Reach of the Columbia River was populated by Native Americans of various tribal affiliations. The Wanapum and the Chamnapum bands of the Yakama[a] tribe lived along the Columbia River from south of Richland upstream to Vantage (Relander 1986; Spier 1936). Some of their descendants still live nearby at Priest Rapids Dam (the Wanapum Tribe); others have been incorporated into the Yakama and Umatilla reservations. Palus people, who lived on the lower Snake River, joined the Wanapum and Chamnapum to fish the Hanford Reach of the Columbia River, and some inhabited the river's east bank (Relander 1986; Trafzer and Scheuerman 1986). Walla Walla and Umatilla people also made periodic visits to fish in the area. These people retain traditional secular and religious ties to the region, and many, young and old alike, have knowledge of the ceremonies and lifeways of their aboriginal culture. The Washane, or Seven Drums religion, which has ancient roots and had its start on what is now the Hanford Site, is still practiced by many people on the Yakama, Umatilla, Warm Springs, and Nez Perce reservations. Native plant and animal foods, some of which can be found on the Hanford Site, are used in the ceremonies performed by sect members.

Native American Lands designated on the Hanford Site fall under the protective rights of the Treaty of 1855 and the National Historic Preservation Act; these will be addressed further in the Cultural Resources Section. Under the Treaties of 1855, lands now occupied by the Hanford Site and other southeastern Washington lands were ceded to the United States by the confederated tribes and bands of the Yakama Indian Nation, the Confederated Tribes of the Umatilla Indian Reservation, and the Nez Perce Tribe. Under these treaties, the Native American tribes obtained the right to perform certain activities on those lands, including the rights to hunt, to fish at all usual and accustomed places and to erect temporary buildings for curing fish, to gather roots and berries, and to pasture horses and cattle on open unclaimed lands. The Wanapum Tribe, although members never signed a treaty, claims similar rights on ceded lands along the Columbia River.

Tribal members have expressed an interest in renewing their use of these resources in accordance with the Treaty of 1855, and the DOE is assisting them in this effort. Certain landmarks, especially Rattlesnake Mountain, Gable Mountain, Gable Butte, Goose Egg Hill, and various sites along the Columbia River, are sacred to them. The many cemeteries found along the river are also considered to be sacred.

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[a] The spelling Yakama rather than Yakima has been adopted by the Yakama Nation.

4.3 Socioeconomics

Activity on the Hanford Site plays a dominant role in the socioeconomics of the Tri-Cities (Richland, Pasco, and Kennewick) and other parts of Benton and Franklin counties. The Tri-Cities serves as a market center for a much broader area of eastern Washington, including Adams, Columbia, Grant, Walla Walla, and Yakima counties. The Tri-Cities also serves parts of northeastern Oregon, including Morrow, Umatilla, and Wallowa counties. Socioeconomic impacts of changes at Hanford are mostly confined to the immediate Tri-Cities community and Benton and Franklin counties (Yakima County to a lesser extent). However, because of the significance of the wider agricultural region and surrounding communities in the Tri-Cities' economic base, this section briefly discusses the wider region as well. Detailed analyses of the socioeconomics are found in Scott et al. (1987) and Watson et al. (1984). Additionally, the impact of the proposed SNF facility might be altered by changes in socioeconomic resources in the surrounding counties of Adams, Columbia, Grant, Walla Walla, and Yakima in Washington state; and Morrow, Umatilla, and Wallowa counties in Oregon (these and Benton and Franklin counties comprise the designated region of influence; see Figure 4-2). This section describes the population, economic activity, housing, and public services and public finance of each county within the region of influence and the Tri-Cities. Because Benton and Franklin counties are expected to be most impacted from changes in Hanford Site activities, the information presented in this section concentrates on those counties, with less attention paid to the other areas within the defined region of influence.

Figure 4-2. Areas of Washington and Oregon where socioeconomic resources may be affected by the proposed spent nuclear fuel facility (designated region of influence).

Table 4.3-1 summarizes the regional (Benton and Franklin counties) projections for employment, labor force, population, and Hanford Site employment by year for the years 1995-2004. Population projections were provided by the Washington State Office of Financial Management (1992a); employment projections were based on projections from the U.S. Department of Commerce (1992); labor force projections were based on an historical average unemployment rate of 8.8%; and Hanford Site employment projections were provided by DOE. It is anticipated at the time of this writing that a down-turn in Hanford Site employment will occur. The extent of the down-turn is unknown.

4.3.1 Demographics

This subsection briefly summarizes pertinent demographic information for each of the counties within the region of influence. Data for Washington were provided by the U.S. Department of Commerce (1992) and the Washington State Office of Financial Management (1992a,b). Data for Oregon were provided by the U.S. Department of Commerce (1992) and the Center for Population Research and Census (1993). Table 4.3-2 summarizes the population figures from 1960 to 1992 for each of the affected counties.

During the period from 1980 to 1990, growth in the affected Washington counties has been less than that of the state, with growth in the counties ranging from -0.07 percent (Columbia County) to 1.22 percent (Grant County) per year. During this same period, annual growth for the state of Washington averaged 1.66 percent. Washington counties within the region of influence also tended to have a younger population, with median ages ranging from 28.7 years to 39.0 years, as compared to the state median age of 33.1 years. These counties also tended to have a larger average household size than the state average, ranging from 2.44 to 3.03 persons, while the state average household size was listed at 2.53 persons.

Table 4.3-3 summarizes population projections through 2005 for each of the counties within the region of influence. All of the Washington counties are expected to experience continued growth, although most have projected growth rates less than that of the state. Washington is projected to have an increase in population of 21.8 percent by 2005 (from 4,866,692 in 1990 to 5,925,888 in 2005) for an annual average increase of 1.45 percent. Growth in the Oregon

Table 4.3-1. Regional economic and demographic indicators.

Year:	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Regional Employment	81,000	81,780	82,570	83,360	84,170	84,900	85,320	85,740	86,170	86,590
Regional Labor Force	88,820	89,670	90,540	91,410	92,290	93,090	93,550	94,020	94,480	94,950
Regional Population	162,660	164,810	166,980	169,180	171,410	173,380	175,730	178,100	180,510	182,950
Site Employment	18,700	16,200	14,700	14,700	14,700	14,700	14,700	14,700	14,700	14,700

Table 4.3-2. Population figures by county in the designated region of influence.

County	1960	1970	1980	1990	1992	1990 Median Age	1990 Average Household

							Size
Adams	9,929	12,014	13,267	13,603	14,100	30.7	2.94
Benton	62,070	67,540	109,444	112,560	118,500	32.1	2.65
Columbia	4,569	4,439	4,057	4,024	4,000	39.0	2.44
Franklin	23,342	25,816	35,025	37,473	39,200	28.7	3.03
Grant	46,477	41,881	48,522	54,758	58,200	31.9	2.74
Walla Walla	42,195	42,176	47,435	48,439	50,500	33.5	2.50
Yakima	145,112	145,212	172,508	188,823	193,900	31.5	2.80
Morrow	4,871	4,465	7,519	7,625	8,092a	-b	-
Umatilla	44,352	44,923	58,861	59,249	60,150a	-	-
Wallowa	7,102	6,247	7,273	6,911	7,135a	-	-

a. 1991 estimate.
b. Dash indicates the information was not available.

Table 4.3-3. Population projections by county in the designated region of influence.

County	1995 Forecast	1990 - 1995 % Change	2000 Forecast	1995 - 2000 % Change	2005 Forecast	2000 - 2005 % Change
Adams	13,867	1.94	14,163	2.14	14,424	1.84
Benton	121,328	7.79	128,752	6.12	136,892	6.32
Columbia	4,025	0.03	4,037	0.30	4,074	0.90
Franklin	41,336	10.31	44,630	7.97	48,213	8.03
Grant	58,026	5.97	60,518	4.30	62,983	4.07
Walla Walla	49,047	1.26	49,910	1.76	50,891	1.97
Yakima	199,578	5.70	207,870	4.15	216,245	4.03
Morrow	8,095	6.16	8,596	6.19	9,157	6.53
Umatilla	62,658	5.75	66,056	5.42	69,506	5.22
Wallowa	7,065	2.23	7,253	2.66	7,496	3.35

counties within the region of influence occurred rapidly during the 1970s; however, since 1980 population growth has tapered off. The Oregon counties within the region of influence are also expected to experience continued growth, although all have projected growth rates less than that of the state. Oregon is projected to have an increase in population of 25.5 percent (from 2,842,321 in 1990 to 3,566,189 in 2005) by 2005 for an annual average increase of 1.70 percent.

Within Benton and Franklin counties, the 1992 estimates distributed the Tri-Cities population as follows: Richland, 33,550; Kennewick, 44,490; and Pasco, 20,840. The combined populations of Benton City, Prosser, and West Richland totaled 10,460 in 1992. The unincorporated population of Benton County was 30,000. In Franklin County, incorporated areas other than Pasco had a total population of 2,540. The unincorporated population of Franklin County was 15,820.

4.3.2 Economics

This subsection summarizes pertinent economic activity within the region of interest and the Tri-Cities, including information on the general economy, employment, income, and impact of the Hanford Site. Historically, the primary industries within the region of influence have been related to agriculture; a multitude of crops encompassing many fruits, vegetables, and grains, are grown each year. Nearly all of the counties in the region of influence are home to food processing industries. Other primary industries within the region of influence include those relating to the wood industry: lumber, wood, and paper products. The data source for the Washington counties was the 1993 Washington State Yearbook (Office of the Secretary of State 1993), and the data source for the Oregon counties data was the 1991-92 Oregon Blue Book (Office of the Secretary of State 1991). Table 4.3-4 summarizes the primary industries, total employment for 1990, and total payroll for 1990 for the region of influence.

4.3.2.1 Employment in the Region of Interest. This subsection provides

information on the employment and payroll breakdown by sector for each county within the region of influence. The source for the Washington counties was Washington State Employment Security Office (1992). The source for the Oregon counties was Department of Human Resources (1990). Tables 4.3-5 and and 4.3-6 provide information on average employment and payroll for 1990, broken down by industry, for each of the counties within the region of influence. For the Washington counties, the average employment includes only persons covered by the Employment Security Act and federal employment covered by Title 5, USC 85. For the Oregon counties, average employment includes only employees of businesses covered by the Employment Division Law.

Table 4.3-4. County economic summary.

County	Primary Industries	1990 Total Employment	1990 Total Payroll ($ Million)
Adams	Food processing, agriculture	6,142	87.2
Benton	Food processing, chemicals, metal products, nuclear products	50,216	1,200.0
Columbia	Agriculture, food processing, wood products	1,559	22.3
Franklin	Food processing, publishing, agriculture, metal fabrication	17,958	284.6
Grant	Food processing, agriculture	20,851	346.0
Walla Walla	Food processing, agriculture, wood and paper products, manufacturing	20,546	366.5
Yakima	Agriculture, food processing, wood products, manufacturing	82,706	1,300.0
Morrow	Agriculture, food processing, utilities, lumber, livestock, recreation	2,791	53.5
Umatilla	Agriculture, food processing, wood products, tourism, manufacturing, recreation	21,448	366.0
Wallowa	Agriculture, livestock, lumber, recreation	2,216	37.9

4.3.2.2 Employment in the Tri-Cities. Three major sectors have been

the principal driving forces of the economy in the Tri-Cities since the early 1970s: (1) the DOE and its contractors, which operate the Hanford Site; (2) Washington Public Power Supply System in its construction and operation of nuclear power plants; and (3) agriculture, including a substantial food-processing industry. With the exception of a minor amount of agricultural commodities sold to local area consumers, the goods and services produced by these sectors are exported from the Tri-Cities. In addition to direct employment and payrolls, these major sectors also support a sizable number of jobs in the local economy through their procurement of equipment, supplies, and business services.

Table 4.3-5. Employment by industry in the region of influence, 1990 figures.

Industry	Adams	Benton	Columbia	Franklin	Grant	Morrow	Umatilla	Walla Walla	Wallowa	Yakima
Agriculture, Forestry, Fisheries	1,660	4,487	105	4,265	4,496	558	1,366	1,890	54	20,342
Mining	0	3	0	89	0	0	0	0	0	641
Construction	0	2,809	27	628	0	33	592	0	86	2,427
Manufacturing	1036	12,310	563	1,599	2,761	884	4,654	3,993	509	9,671
Transportation and Public Utilities	236	884	58	1,212	657	153	899	593	85	2,824
Wholesale Trade	581	932	57	1,279	1,156	70	1,201	760	76	7,101
Retail Trade	720	7,865	120	2,669	3,109	195	3,845	3,639	360	12,537
Finance, Insurance, Real Estate	120	1,342	24	358	432	50	590	718	82	1,904
Services	564	11,741	144	2,768	2,512	142	3,416			

								4,207	204	14,491
Government	1,132	7,843	461	3,091	4,618	697	4,823	4,308	739	11,368
Not Elsewhere Classified	93	0	0	0	1,110	8	63	438	23	0

Table 4.3-6. Payroll by industry in the region of influence, 1990 figures ($ million).

Industry[a]	Adams	Benton	Columbia	Franklin	Grant	Walla Walla	Yakima	Morrow	Umatill	Wallowa
Agriculture, Forestry, Fisheries	14.7	39.1	1.5	39.1	47.9	18.4	173.4	9.0	18.7	0.7
Mining	0	0.1	0	2.3	0	0	0.6	0	0	0
Construction	0	79.3	1.0	12.7	0	0	47.7	0.5	11.9	2.1
Manufacturing	19.6	443.9	7.3	28.4	59.7	94.0	205.2	19.3	88.2	11.2
Transportation and Public Utilities	3.9	21.2	1.2	25.1	14.4	14.1	62.5	6.2	19.6	1.6
Wholesale Trade	10.7	19.2	1.1	26.3	21.4	15.6	118.4	1.5	22.2	1.2
Retail Trade	7.1	89.0	1.0	31.5	30.3	36.1	143.0	1.5	41.8	3.8
Finance, Insurance, Real Estate	2.0	22.0	0.4	6.2	7.6	13.2	39.0	1.0	10.6	1.0
Services	6.3	286.4	1.2	42.2	28.0	66.6	226.1	1.3	48.3	2.2
Government	21.2	225.8	7.7	70.8	107.0	100.0	258.0	12.8	103.6	13.7
Not Elsewhere Classified	1.6	0	0	0	29.7	8.6	0	0.2	1.0	0.3

1) The DOE and its Contractors (Hanford). Hanford continued to dominate the local employment picture with almost one-quarter of the total nonagricultural jobs in Benton and Franklin counties in 1992 (16,100 of 67,300). Hanford's payroll has a widespread impact on the Tri-Cities economy and state economy in addition to providing direct employment. These effects are further described in Subsection 4.3.

2) Washington Public Power Supply System. Although activity related to nuclear power construction ceased with the completion of the WNP-2 reactor in 1983, the Washington Public Power Supply System continues to be a major employer in the Tri-Cities area. Headquarters personnel based in Richland oversee the operation of one generating facility and perform a variety of functions related to two mothballed nuclear plants and one standby generating facility. In 1992, the Washington Public Power Supply System headquarters employment was more than 1700 workers. Washington Public Power Supply System activities generated a payroll of approximately $80.4 million in the Tri-Cities during the year.

3) Agriculture. In 1990 agricultural activities in Benton and Franklin counties were responsible for approximately 12,900 jobs, or 17 percent of the area's total employment. According to the U.S. Department of Commerce's Regional Economic Information System, about 2200 people were classified as farm proprietors in 1990. Farm proprietors' income from this same source was estimated at $121 million in the same year.

Crop and livestock production in the bicounty area generated about 7600 wage and salary jobs in 1990, as represented by the employees covered by unemployment insurance. The presence of seasonal farm workers would increase the total number of farm workers. Apart from the difficulty of obtaining reliable information on the number of seasonal workers, however, is the question of how much of these earnings are actually spent in the local area. For this analysis, the assumption is that the impact of seasonal workers on the local economy is sufficiently small to be safely ignored.

The area's farms and ranches generate a sizable number of jobs in supporting activities, such as agricultural services (for example, application of pesticides and fertilizers or irrigation system development) and sales of farm supplies and equipment. These activities, often called agribusiness, are estimated to employ 900 people. Although formally classified as a manufacturing activity, food processing is a natural extension of the farm sector. More than 20 food processors in Benton and Franklin counties produce such items as potato products, canned fruits and vegetables, wine, and animal feed.

In addition to those three major employment sectors, three other components are readily identified as contributors to the economic base of the Tri-Cities economy. The first component, categorized as other major employers, includes five employers: (1) Siemens Nuclear Power Corporation in north Richland, (2) Sandvik Special Metals in Kennewick, (3) Boise-Cascade in Wallula, (4) Burlington Northern Railroad in Pasco, and (5) Iowa Beef Processors in Wallula. The second component is tourism. The Tri-Cities area has increased its convention business substantially in recent years, in addition to business generated by travel for recreation. The final component in the economic base relates to the local purchasing power generated from retired former employees. Government transfer payments in the form of pension benefits constitute a significant proportion of total spendable income in the local economy.

Retirees. Although the Benton and Franklin counties have a relatively young population (approximately 56 percent under the age of 35), 15,093 people over the age of 65 resided in Benton and Franklin counties in 1990. The portion of the total population that is 65 years and older is currently increasing at about the same rate as that being experienced by Washington State (3.0 percent and 3.1 percent, respectively). This segment of the population supports the local economy on the basis of income received from government transfer payments and pensions, private pension benefits, and prior individual savings.

Although information on private pensions and savings is not available, data are available regarding the magnitude of government transfer payments. The U.S. Department of Commerce's Regional Economic Information System has estimated transfer payments by various programs at the county level. A summary of estimated major government pension benefits received by the residents of Benton and Franklin counties in 1990 is shown in Table 4.3-7. About two-thirds of the Social Security payments go to retired workers; the remainder are for disability and other payments. The historical importance of government activity in the Tri-Cities area is reflected in the relative magnitude of the government employee pension benefits as compared to total payments.

Table 4.3-7. Government retirement payments in Benton and Franklin counties in 1990 ($ million).

Source	Benton County	Franklin County	Total
Social Security (including survivors and disability)	101.5	31.1	132.6
Railroad retirement	2.7	3.6	6.3
Federal civilian retirement	10.5	2.8	13.3
Veterans pension and military retirement	14.7	3.1	17.8
State and local employee retirement	22.3	5.5	27.8
Total	151.7	46.1	197.8

4.3.2.3 Income Sources. Three measures of income are presented in

Table 4.3-8: total personal income, per capita income, and median household **income.** Total personal income is comprised of all forms of income received by the populace, including wages, dividends, and other revenues. Per capita income is roughly equivalent to total personal income divided by the number of people residing in the area. Median household income is the point at which half of the households have an income greater than the median and half have less. The source for total personal income and per capita income was the U.S. Department of Commerce's Regional Economic Information System; while median income figures for Washington State were provided in Washington State Office of Financial Management (1992b), and by personal communication with the Bureau of Census Housing Division for Oregon.

In 1990 the total personal income for the Washington was $92.2 billion; of this, the counties within the region of influence comprised 8.0 percent. Per capita income for Washington State was $18,777; all Washington counties within the region of influence had per capita incomes less than that of the state. All Washington counties within the region of influence, with the exception of Benton, had median household incomes less than the state median of $32,725.

In 1990 the total personal income for Oregon was $49.2 billion; of this, the counties within the region of influence comprised 2.4 percent. Per capita income for Oregon State was $17,182; two of the three affected Oregon counties had per capita incomes greater than that of the state in 1990; however, only one of the three counties had a median household income greater than the state median of $27,250.

Table 4.3-8. Income measures by county, 1990 figures.

County	Total Personal Income ($ Million)	Per Capita Income ($)	Median Income ($)
Adams	231	16,897	25,750

Benton	1,960	17,332	33,800
Columbia	72	17,927	21,000
Franklin	553	14,734	26,300
Grant	854	15,511	23,625
Walla Walla	799	16,438	25,400
Yakima	2,920	15,374	24,525
Morrow	144	18,868	29,969
Umatilla	896	15,069	22,791
Wallowa	121	17,461	21300

4.3.2.4 Hanford Employment. In 1991 Hanford employment accounted

directly for 24 percent of total nonagricultural employment in Benton and Franklin counties and slightly more than 0.6 percent of all statewide nonagricultural jobs. In 1991 Hanford Site operations directly accounted for an estimated 42 percent of the payroll dollars earned in the area.

Previous studies have revealed that each Hanford job supports about 1.2-additional jobs in the local service sector of Benton and Franklin counties (about 2.2 total jobs) and about 1.5 additional jobs in the state's service sector (about 2.5 total jobs) (Scott et al. 1987). Similarly, each dollar of Hanford income supports about 2.1 dollars of total local incomes and about 2.4 dollars of total statewide incomes. Based on these multipliers, Hanford directly or indirectly accounts for more than 40 percent of all jobs in Benton and Franklin counties.

Based on employee residence records as of December 1993, 93 percent of the direct employment of Hanford is comprised of residents of Benton and Franklin counties. Approximately 81 percent of the employment is comprised of residents who reside in one of the Tri-Cities. More than 42 percent of the employment is comprised of Richland residents, 30 percent of Kennewick residents, and 9 percent of Pasco residents. West Richland, Benton City, Prosser, and other areas in Benton and Franklin counties account for 12 percent of total employment. Table 4.3-9 contains the estimated percent of Hanford employees residing in each of the counties within the region of influence. The information available did not include the residences of DOE employees nor those of ICF Kaiser Hanford Company or the Bechtel Hanford Company. It was assumed that the distribution of these employees would be similar to the distribution of the other Hanford contractors.

Table 4.3-9. Hanford employee residences by county.

County	Percent of Employees in Residence
Adams	0.18%
Benton	84.16%
Columbia	0.01%
Franklin	9.07%
Grant	0.25%
Walla Walla	0.21%
Yakima	5.08%
Morrow	0.01%
Umatilla	0.01%

Hanford and contractors spent nearly $298 million, or 45.6 percent of total procurements of $653 million, initially through Washington firms in 1993. About 18 percent of Hanford orders were filled by Tri-Cities firms.

Hanford contractors paid a total of $10.9 million in state taxes on operations and purchases in fiscal year 1988 (the most recent year available). Estimates show that Hanford employees paid $27.0 million in state sales tax, use taxes, and other taxes and fees in fiscal year 1988. In addition, Hanford paid $0.9 million to local government in Benton, Franklin, and Yakima counties in local taxes and fees (Scott et al. 1989).

4.3.3 Emergency Services

This subsection contains information on the law enforcement, fire protection, and health services provided by each county within the region of influence. These figures are presented in Table 4.3-10, with more detailed information about the Tri-Cities area. Law enforcement figures were obtained from each county sheriff's office in December 1993. Data on fire protection and health care facilities were provided by the Office of the Secretary of State (1993).

Table 4.3-10. Emergency services within the region of influence.

County	Commissioned Officers - County Sheriff	Number of Fire Districts - Unincorporated	Number of Hospitals
Adams	16 + Sheriff	7	2
Benton	40	6	3
Columbia	10 + Sheriff	3	1
Franklin	18 + Sheriff	4	1
Grant	35 + Sheriff	12	1
Walla Walla	16 + Sheriff	8	2
Yakima	63	12	3
Morrow	70	NA	NA
Umatilla	12	NA	NA
Wallowa	5	NA	NA

Police protection in Benton and Franklin counties is provided by the Benton and Franklin County sheriff's departments, local municipal police departments, and the Washington State Patrol Division headquartered in Kennewick. Table 4.3-11 shows the number of commissioned officers and patrol cars in each department in June 1992.

Table 4.3-11. Police personnel in the Tri-Cities in 1992.

Area	Commissioned Officers	Patrol Cars
Kennewick Municipal	58	32
Pasco Municipal	39	11
Richland Municipal	44	35
West Richland Municipal	7	9
County Sheriff, Benton County	43	50
County Sheriff, Franklin County	23	23

Source: Personal communication with each department office, January 1993.

The Kennewick, Richland, and Pasco municipal departments maintain the largest staffs of commissioned officers with 53, 44, and 38, respectively.

The Hanford Fire Department, composed of 126 firefighters, is trained to dispose of hazardous waste and to fight chemical fires. During the 24-hour duty period, five firefighters cover the 1100 Area, seven protect the 300 Area, seven watch the 200-East and 200-West Areas, six are responsible for the 100 Areas, and six cover the 400 Area, which includes the WPPSS area. To perform their responsibilities, each station has access to a Hazardous Material Response Vehicle that is equipped with chemical fire extinguishing equipment, an attack truck that carries foam and Purple-K dry chemical, a mobile air truck that provides air for gasmasks, and a transport tanker that supplies water to six brush-fire trucks. The Hanford Fire Patrol owns five ambulances and maintains contact with local hospitals.

Table 4.3-12 indicates the number of fire-fighting personnel, both paid and unpaid, on the staffs of fire districts in the Tri-Cities area.

The Tri-Cities area is served by three hospitals: Kadlec Hospital, Kennewick General, and Our Lady of Lourdes. In addition, the Carondelet Psychiatric Care Center is located in Richland. Kadlec Hospital, located in Richland, has 136 beds and functions at 39.5 percent capacity. Their 5754 annual admissions represent more than 42 percent of the Tri-Cities market. Non-Medicare/Medicaid patients accounted for 86 percent, or 4982 of their annual admissions. An average stay of 3.8 days per admission was reported for 1991.

Table 4.3-12. Fire protection in the Tri-Cities in 1992[a].

Station	Fire-Fighting Personnel	Volunteers	Total	Service Area
Kennewick	54	0	54	City of Kennewick
Pasco	30	0	30	City of Pasco
Richland	50	0	50	City of Richland
BCRFD[b] 1	6	120	126	Kennewick Area
BCRFD 2	1	31	32	Benton City
BCRFD 4	4	30	34	West Richland

a. Source: Personal communication with each department office, January 1993.

b. BCRFD = Benton County Rural Fire Department.

Kennewick General Hospital maintains a 45.5 percent occupancy rate of its 71 beds with 3619 annual admissions. Non-Medicare/Medicaid patients in 1991 represented 58 percent of its total admissions. An average stay of 3.5 days per admission was reported.

Our Lady of Lourdes Health Center, located in Pasco, reported an occupancy rate of 36.5 percent; however, a significant amount of outpatient care is performed there. The out patient income serves as a primary source of income for the center. In 1990 Our Lady of Lourdes had 3328 admissions, of which 52 percent were non-Medicare/Medicaid patients. The institution reported an average admission stay of 5.33 days.

4.3.4 Infrastructure

4.3.4.1 Housing. This section provides information on the total number

of housing units, the number of occupied housing units, and a breakdown of total housing units by type for each of the counties within the region of influence. Additionally, specific information on the housing market in the Tri-Cities is included. The data source for Washington counties was the Washington State Office of Financial Management (1992b). The data source for the Oregon counties was by personal communication with the Population Research Center at Portland State University. The data source for the Tri-Cities was by personal communication with the Washington State Office of Financial Management. Table 4.3-13 summarizes housing information by county for 1990 for the region of influence.

In 1993 nearly 94 percent of all housing (of 40,344 total units) in the Tri-Cities was occupied. Single-unit housing, which represents nearly 58 percent of the total units, had a 97 percent occupancy rate throughout the Tri-Cities. Multiple-unit housing, defined as housing with two or more units, had an occupancy rate of nearly 94 percent. Pasco had the lowest occupancy rate, 92 percent, in all categories of housing; followed by Kennewick, 95 percent, and Richland, 96 percent. Mobile homes, which represent 9 percent of the housing unit types, had the lowest occupancy rate, 90 percent. In 1989 mobile homes had the highest occupancy rate, 93 percent. Table 4.3-14 shows a detailed listing of total units and occupancy rate by type in the Tri-Cities.

Table 4.3-13. Housing by county in 1990.

County	Total	Occupied	Vacancy Rate	Single Family	Multiple Family	Mobile Homes
Adams	5,263	4,586	12.9%	3,324	643	1,296
Benton	44,877	42,227	5.9%	28,193	10,592	6,092
Columbia	2,046	1,582	22.7%	1,597	146	303
Franklin	13,664	12,196	10.7%	7,782	3,289	2,593
Grant	22,809	19,745	13.4%	13,692	2,661	6,456
Walla Walla	19,029	17,623	7.4%	13,071	3,837	2,121
Yakima	70,852	65,985	6.9%	49,356	11,174	10,322
Morrow	3,412	2,803	17.8%	1,828	366	1,192
Umatilla	24,333	22,020	9.5%	15,178	4,503	4,418
Wallowa	3,755	2,796	25.5%	2,935	235	554

4.3.4.2 Human Services. The Tri-Cities offer a broad range of social

services. State human service offices in the Tri-Cities include the Job Services office of the Employment Security Department; Food Stamp offices; the Division of Developmental Disabilities; Financial and Medical Assistance; the Child Protective Service; emergency medical service; a senior companion program; and vocational rehabilitation.

Table 4.3-14. Total units and occupancy rates (1993 estimates)a.

City	All Units	Rate	Single Units	Rate	Multiple Units	Rate	Mobile Homes	Rate
Richland	14,388	96	9,921	98	3,827	95	640	88
Pasco	7,846	92	3,679	96	2,982	91	1,016	86
Kennewick	18,110	95	9,824	97	5,944	96	1,942	97
Tri-Cities	40,344	94	23,424	97	12,753	94	3,598	90

a. Source: Personal communication, Office of Financial Management, State of Washington, Forecast Division.

The Tri-Cities are also served by a large number of private agencies and voluntary human services organizations. The United Way, an umbrella fund-raising organization, incorporates 25 participating agencies offering more than 50 programs (United Way 1992).

4.3.4.3 Government. This subsection presents the county government

revenues by source (Table 4.3-15) and expenditures by function (Table 4.3-16) for each of the counties within the region of influence. The data were taken from U.S. Department of Commerce (1990, 1993). All county data, with the exception of Benton and Yakima counties, are from 1986-87. Benton and Yakima county data are from 1990-91. These years were the most recent ones available.

4.3.4.4 Public Education. This subsection provides information on the

educational sectors of each of the counties. The source for school district information, secondary education, and enrollment data for the Washington counties was the Office of the Secretary of State (1993); student/teacher ratios were provided by personal communication with the school districts. Information on the Oregon counties was provided by personal communication with the individual counties. Table 4.3-17 summarizes information on the number of school districts, enrollment, and post-secondary institutions within the region of influence.

In the Tri-Cities area, Benton County primary and secondary education is served by six school districts with an enrollment of 24,876 students in 1992. The student/teacher ratio in the Finley School District is 20.2; in Kennewick, 24.0; in Kiona Benton-City, 25.0; in Prosser, 22.0 for elementary and 25.0 for secondary; and in Richland, 23.0. The Paterson School District had an enrollment of 54 students in 1992, therefore a student/teacher ratio was not sought. Currently, the Kennewick, Richland, and Kiona-Benton City school districts are operating at or near capacity; Kennewick is working to alleviate some of the overcrowded conditions by constructing one new middle school and two new elementary schools. In addition, plans are under way for the construction of a new high school, scheduled to open in 1997. Kiona-Benton City is in the process of building additions at elementary and middle schools. The county also has a post-secondary institution located in Richland, a branch campus of Washington State University, WSU Tri-Cities. Enrollment for spring 1992 was 981 students.

Franklin County primary and secondary education is served by four school districts with an enrollment of 8,756 students in 1992 and a student/teacher ratio of 7.0 in Kahlotus; 17.6 in

Table 4.3-15. Revenue sources by county FY 1986-87 ($ thousand).

Intergovernmental

General revenue from

revenue

own

sources

Utility, liquor

store, and

employee

retirement

revenue

County	Total	Total	From federal government	From state government	Total	Taxes	
Adams	6,690	6,690	736	2,844	3,047	2,304	-[a]
Benton[b]	24,079	24,079	43	7,879	14,064	10,762	-
Columbia	2,560	2,560	78	1,388	1,040	720	-
Franklin	6,279	6,279	361	109	5,604	4,859	-
Grant	17,525	17,525	670	7,661	8,932	6,195	-
Walla Walla	11,698	11,698	426	3,763	7,008	5,658	-
Yakima[b]	45,310	45,289	392	14,066	28,864	20,429	21
Morrow	5,901	5,901	104	1,045	4,724	3,338	-
Umatilla	9,594	9,594	204	4,971	4,414	3,087	-
Wallowa	6,215	6,215	60	2,180	3,881	905	-

a. Dash indicates that the information was not available.
b. FY 1990-91.

Table 4.3-16. Expenditures by county FY 1986-87 ($ thousand).

General Expenditures

Major Functions

County	Total	Total	Capital Outlay	Education	Welfare	Hospitals	Health	Highways	Police protection	Correction	Natural resources and parks and recreation	Sewage and sanitation	Interest on general debt	Utility, liquor store, and employee retirement expenditure
Adams	6431	6431	1007	13	-[a]	-	286	3591	475	297	138	184	22	-
Benton[b]	22027	22027	890	9	-	-	3626	3190	1956	4129	216	-	223	-
Columbia	2647	2647	255	-	-	-	230	1106	265	13	306	84	-	-
Franklin	8230	8230	608	-	-	-	461	2883	855	811	177	-	49	-
Grant	17589	17589	3314	-	-	-	1403	6617	1443	1180	704	412	22	-
Walla Walla	11879	11879	432	4	-	-	1068	4624	1257	610	766	143	-	-
Yakima[b]	45967	45937	10059	-	187	-	989	9761	4188	7382	2971	415	487	30
Morrow	6382	6382	411	216	349	1113	325	1860	270	98	237	-	-	-
Umatilla	10707	10707	188	1095	-	-	2562	2337	540	561	346	-	-	-
Wallowa	6139	6139	362	339	794	2070	143	1181	208	111	198	67	9	-

a. Dash indicates that the information was not available.

b. FY 1990-91.

Table 4.3-17. Educational services by county in 1992.

County	Number of School Districts	Enrollment (1992)	Post-Secondary Education Institutions
Adams	5	3,437	0
Benton	6	24,876	1
Columbia	2	750	0
Franklin	4	8,756	1
Grant	10	13,232	1
Walla Walla	7	8,324	3
Yakima	15	42,227	3
Morrow	1	2,008a	0
Umatilla	12	12,500a	1
Wallowa	3	1,408a	0

a. 1993 enrollment

North Franklin; and 18.1 in Pasco. The Star School District had an enrollment of 15 students in 1992; therefore, a student/teacher ratio was not sought. Currently, Pasco School District is operating at or near capacity; however, the district is in the process of remodeling an old high school. The county also has a post-secondary institution of learning in Pasco, Columbia Basin Community College. Enrollment for 1992 was 6424 students.

4.4 Cultural Resources

The Hanford Site is known to be rich in cultural resources. It contains numerous, well-preserved archaeological sites representing both the prehistoric and historical periods and is still thought of as a homeland by many Native American people. A total of 248 known sites are prehistoric, 202 are historic, and 14 sites contain both prehistoric and historic components. Management of Hanford's cultural resources follows the Hanford Cultural Resources Management Plan (Chatters 1989) and is conducted by the Hanford Cultural Resources Laboratory of Pacific Northwest Laboratory (PNL). The Plan contains contingency guidelines for handling the discovery of previously unknown cultural resources encountered during construction activities.

Cultural resources are defined as any prehistoric or historic district, site, building, structure, or object considered to be important to a culture, subculture, or community for scientific, traditional, religious or any other reason. These are usually divided into three major categories: prehistoric and historic archaeological resources, architectural resources, and traditional cultural resources. Significant cultural resources are those that are eligible or potentially eligible to the National Register of Historic Places (36 CFR 60.4).

Consultation is required to identify traditional cultural properties that are important to maintaining the cultural heritage of Native American Tribes. Under the Treaties of 1855, lands ultimately occupied by the Hanford Site were ceded to the United States by the confederated tribes and bands of the Yakama Indian Nation, and Confederated Tribes of the Umatilla Indian Reservation. Under the treaty, the Native American Tribes acquired the rights to perform certain activities on open unclaimed lands, including the rights to hunt, fish, gather foods and medicines, and pasture livestock on these lands. By the time the Hanford Site was established, little open unclaimed land remained. The Wanapum Band and the Joseph Band of the Nez Perce Tribes never signed a treaty but have cultural ties to these lands.

The methodology for identifying, evaluating, and mitigating impacts to cultural resources is defined by federal laws and regulations including the National Historic Preservation Act (NHPA), the Archaeological Resource Protection Act (ARPA), the Native American Graves Protection and Repatriation Act (NAGPRA) and the American Native American Religious Freedom Act (AIRFA). A project affects a significant resource when it alters the property's characteristics, including relevant features of its environment or use, that qualify it as significant according to the National Register criteria. These effects may include those listed in 36 CFR 800.9. Impacts to traditional Native American properties can be determined only through consultation with the affected Native American groups.

4.4.1 Prehistoric Archaeological Resources

People have inhabited the Middle Columbia River region since the end of the glacial period. More than 10,000 years of prehistoric human activity in this largely arid environment have left extensive archaeological deposits along the river shores (Leonhardy and Rice 1970; Greengo 1982; Chatters 1989). Well-watered areas inland from the river show evidence of concentrated human activity (Chatters 1982, 1989; Daugherty 1952; Greene 1975; Leonhardy and Rice 1970; Rice 1980), and recent surveys indicate extensive, although dispersed, use of arid lowlands for hunting. Graves are common in various settings, and spirit quest monuments are still to be found on high, rocky summits of the mountains and buttes (Rice 1968a). Throughout most of the region, hydroelectric development, agricultural activities, and domestic and industrial construction have destroyed or covered the majority of these deposits. Amateur artifact collectors have had an immeasurable impact on what remains. Within the Hanford Site, from which the public is restricted, archaeological deposits found in the Hanford Reach of the Columbia River and on adjacent plateaus and mountains have been spared some of the disturbances that have befallen other sites. The Hanford Site is thus a de facto reserve of archaeological information of the kind and quality that has been lost elsewhere in the region.

Currently 248 prehistoric archaeological sites are recorded in the files of the Hanford Cultural Resources Laboratory. Of 48 sites included on the National Register of Historic Places (National Register), two are single sites, Hanford Island Site (45BN121) and Paris Site (45GR317), and the remainder are located in seven archaeological districts (Table 4.4-1). In addition, a draft request for Determination of Eligibility has been prepared for one traditional cultural property district (Gable Mountain/Gable Butte). Three other sites, Vernita Bridge (45BN90) and Tsulim (45BN412), and 45BN163, are considered eligible for the National Register. Archaeological sites include remains of numerous pithouse villages, various types of open campsites, and cemeteries along the river banks (Rice 1968a, 1980), spirit quest monuments (rock cairns), hunting camps, game drive complexes, and quarries in mountains and rocky bluffs (Rice 1968b), hunting/kill sites in lowland stabilized dunes, and small temporary camps near perennial sources of water located away from the river (Rice 1968b).

Many recorded sites were found during four archaeological reconnaissance projects conducted between 1926 and 1968 (Krieger 1928; Drucker 1948; Rice 1968a, 1968b). Systematic archaeological surveys conducted from the middle 1980s through 1993 are responsible for the remainder (e.g., Chatters 1989; Chatters and Cadoret 1990; Chatters and Gard 1992; Chatters et al. 1990, 1991, 1992, 1993). Little excavation has been conducted at any of the sites, and the Mid-Columbia Archaeological Society has done most of that work. They have conducted minor test excavations at several sites on the river banks and islands (Rice 1980) and a larger scale test at site 45BN157 (Den Beste and Den Beste 1976). The University of Idaho also excavated a portion of site 45BN179 (Rice 1980) and collaborated with the Mid-Columbia Archaeological Society on its other work. Test excavations have been conducted by the Hanford Cultural Resources Laboratory at the Wahluke (45GR306), Vernita Bridge (45BN90), and Tsulim (45BN412) sites and at 45BN446, 45BN423, 45BN163, 45BN432, and 45BN433; results support assessments of significance for those sites. Most of the archaeological survey and reconnaissance activity has concentrated on islands and on a strip of land less than 400 meters wide on either side of the river (Rice 1980), but this is changing because of a Hanford Cultural Resources Laboratory effort to inventory a 10 percent sample of the site by 1994. During his reconnaissance of the Hanford Site in 1968, Rice inspected portions of Gable Mountain, Gable Butte, Snively Canyon, Rattlesnake Mountain, and Rattlesnake Springs but gave little attention to other areas (Rice 1968b). He also inspected additional portions of Gable Mountain and part of Gable Butte in the late 1980s (Rice 1987). Other reconnaissance of the Basalt Waste Isolation Project Reference Repository Location (RRL) (Rice 1984) included a proposed land exchange in T22N, R27E, Section 33 (Rice 1981), and three narrow transportation and utility corridors (Ertec Northwest, Inc. 1982; Morgan 1981; Smith et al. 1977). The 100 Areas were surveyed in 1991 through 1993, revealing a large number of new archaeological sites (Chatters et al. 1992; Wright 1993). To date only about

Table 4.4-1. Archaeological districts and historic properties on the Hanford Site listed on the National Register of Historic Places (with their archaeological sites).

District/Property Name	Site(s) Included
Wooded Island A.D.	45BN107 through 45BN112, 45BN168
Savage Island A.D.	45BN116 through 45BN119, 45FR257 through 45FR262
Hanford Island Site	45BN121
Hanford North A.D.	45BN124 through 45BN134, 45BN178
Locke Island A.D.	45BN137 through 45BN140, 45BN176, 45GR302 through 45GR305
Ryegrass A.D.	45BN149 through 45BN157
Paris Site	45GR317
Rattlesnake Springs A.D.	45BN170, 45BN171
Snively Canyon A.D.	45BN172, 45BN173
100-B Reactor	NA[b]

a. A.D. indicates archaeological district (this table).
b. Not applicable.

6 percent of the Hanford Site has been surveyed. Cultural resource reviews are conducted when projects are proposed for areas that have not been previously reviewed; about 100 to 120 reviews were conducted annually through 1991; this figure rose to more than 400 reviews during 1993.

4.4.2 Native American Cultural Resources

In prehistoric and early historic times, the Hanford Reach of the Columbia River was heavily populated by Native Americans of various tribal affiliations. The Wanapum and the Chamnapum band of the Yakama tribe dwelt along the Columbia River from south of Richland upstream to Vantage (Relander 1956; Spier 1936). Some of their descendants still live nearby at Priest Rapids, and others have been incorporated into the Yakama and Umatilla reservations. Palus people, who lived on the lower Snake River, joined the Wanapum and Chamnapum to fish the Hanford Reach of the Columbia River and some inhabited the river's east bank (Relander 1956; Trafzer and Scheuerman 1986). Walla Walla and Umatilla people also made periodic visits to fish in the area. These people retain traditional secular and religious ties to the region, and many, young and old alike, have knowledge of the ceremonies and lifeways of their aboriginal culture. The Washane, or Seven Drums religion, which has ancient roots and had its start on what is now the Hanford Site, is still practiced by many people on the Yakama, Umatilla, Warm Springs, and Nez Perce reservations. Native plant and animal foods, some of which can be found on the Hanford Site, are used in the ceremonies performed by sect members.

4.4.3 Historic Archaeological Resources

The first Euro-Americans who came to this region were Lewis and Clark, who traveled along the Columbia and Snake rivers during their 1803-1806 exploration of the Louisiana Territory. They were followed by fur trappers, who also passed through on their way to more productive lands upriver and downstream and across the Columbia Basin. It was not until the 1860s that merchants set up stores, a freight depot, and the White Bluffs Ferry on the Hanford Reach. Chinese miners began to work the gravel bars for gold. Cattle ranches opened in the 1880s and farmers soon followed. Several small, thriving towns, including Hanford, White Bluffs, and Ringold, grew up along the riverbanks in the early 20th century. Other ferries were established at Wahluke and Richmond. The towns and nearly all other structures were razed after the U.S. Government acquired the land for the Hanford Nuclear Reservation in the early 1940s (Chatters 1989; Ertec Northwest, Inc. 1981; Rice 1980).

Historic archaeological sites totaling 202 and 11 other historic localities have been recorded by the Hanford Cultural Resources Laboratory on the Hanford Site. Localities include the Allard Pumping Plant at Coyote Rapids, the Hanford Irrigation Ditch, the Hanford townsite, Wahluke Ferry, the White Bluffs townsite, the Richmond Ferry, Arrowsmith townsite, a cabin at East White Bluffs ferry landing, the White Bluffs road, the old Hanford High School, and the Cobblestone Warehouse at Riverland (Rice 1980). Archaeological sites including the East White Bluffs townsite and associated ferry landings and an assortment of trash scatters, homesteads, corrals, and dumps have been recorded by the Hanford Cultural Resources Laboratory since 1987. Ertec Northwest, Inc. was responsible for minor test excavations at some of the historic sites, including the Hanford townsite locality. In addition to the recorded sites, numerous unrecorded site areas of gold mine tailings along the river bank and the remains of homesteads, farm fields, ranches, and abandoned Army installations are scattered over the entire Hanford Site. Of these historic sites, one is included in the National Register as an historic site, and 56 are listed as archeological sites.

More recent locations are the defense reactors and associated materials processing facilities that now dominate the site. The first reactors (B, D, and F) were constructed in 1943 as part of the Manhattan Project. Plutonium for the first atomic explosion and the bomb that destroyed Nagasaki to end World War II was produced in the B Reactor. Additional reactors and processing facilities were constructed after World War II during the Cold War. All reactor containment buildings still stand, although many ancillary structures have been removed. The B Reactor has been listed on the National Register of Historic Places. A historic context for Manhattan Project facilities has been created as part of a Multiple Property Document. Until a full evaluation of all Manhattan Project buildings and facilities has been completed, statements about National Register status cannot be made.

4.4.4 200 Areas

An archaeological survey has been conducted of all undeveloped portions of the 200-East Area, and a 50 percent random sample has been conducted of undeveloped portions of the 200-West Area. The old White Bluffs freight road (see Rice 1984) crosses diagonally through the 200-West Area. The road, formerly a Native American trail, has been in continuous use since antiquity and has played a role in Euro-American immigration, development, agriculture, and Hanford Site operations. The road has been found to be eligible for listing on the National Register of Historic Places. A 100-m easement has been created to protect the road from uncontrolled disturbance. Historic buildings that have not been evaluated for National Register eligibility occur in both the 200-East and 200-West Areas.

4.5 Aesthetic and Scenic Resources

The land in the vicinity of the Hanford Site is generally flat with little relief. Rattlesnake Mountain, rising to 1060 meters (3477 feet) above mean sea level, forms the western boundary of the site. Gable Mountain and Gable Butte are the highest land forms within the site. The view toward Rattlesnake Mountain is visually pleasing, especially in the springtime when wildflowers are in bloom. Large rolling hills are located to the west and far north. The Columbia River, flowing across the northern part of the site and forming the eastern boundary, is generally considered scenic, with its contrasting blue against a background of brown basaltic rocks and desert sagebrush. The White Bluffs, steep whitish-brown bluffs adjacent to the Columbia River and above the northern boundary of the river in this region, are a striking feature of the landscape.

The potential project site (under all alternatives except No Action) is characterized by large sagebrush, desert grasses, and shrubs. Immediate views to the east include the 200-East Area facilities, views in the distant north area of reactors. Somewhat hidden by a slight rise in the land are stacks for facilities in 200-West Area to the west of the project site. To the south southwest are gravel borrow pit and radio and meteorological towers. This site is of low sensitivity in terms of aesthetic and scenic resources.

4.6 Geology

This section summarizes the geologic setting, including potential geologic hazards, at the Hanford Site. Physiography, structure, soils, and seismicity and volcanic hazards are briefly discussed. A more detailed discussion of these subjects can be found in Cushing (1992).

4.6.1 General Geology

The Hanford Site lies within the Columbia Intermontane physiographic province, bordered on the north and east by the Rocky Mountains and on the west by the Cascade Range. The dominant geologic characteristics of the Hanford Site have resulted from basaltic volcanism and ancient catastrophic flooding.

Fluvial and lacustrine processes associated with the ancestral Columbia River system, including the ancestral Snake and Yakima rivers, have been active since the late Miocene. Deposits of these rivers and lakes are represented by the Ringold Formation and indicate that deposition was almost continuous from about 10.5 million years before present until about 3.9 million years before present (DOE 1988). At some time before 900,000 years ago, a major change in regional base level resulted in fluvial incision of as much as 150 meters (500 feet). The post-Ringold erosional surface was partially filled with locally derived alluvium and fluvial sediment before and possibly between periods of Pleistocene flooding. However, in most areas of the Columbia Basin subprovince, the record of Pleistocene fluvial activity was destroyed by cataclysmic flooding. Loess (buff-colored silt) occurs in sheets that mantle much of the upland areas of the Columbia Basin subprovince.

Quaternary(a) volcanism has been limited to the extreme western margin of the Columbia Basin subprovince and is associated with the Cascade Range Province. Airfall tephra(b) from at least three Cascade volcanoes has blanketed the central Columbia Plateau since the late Pleistocene. This tephra includes material from several eruptions of Mount St. Helens before the May 1980 eruption. Other volcanoes have erupted less frequently; two closely spaced eruptions from Glacier Peak about 11,200 years ago, and the eruption of - Mount Mazama about 6,600 years ago. Generally tephra layers have not exceeded more than a few centimeters in thickness, with the exception of the Mount Mazama eruption when as much as 10 centimeters (3.9 inches) of tephra fell over eastern Washington (DOE 1988).

4.6.1.1 Physiography. The Hanford Site, located within the Pasco Basin of

the Columbia Plateau, is defined generally by a thick accumulation of basaltic lava flows that extend laterally from central Washington eastward into Idaho and southward into Oregon (Tallman et al. 1979).

The Hanford Site overlies the structural low point of the Pasco Basin near the confluence of the Yakima and Columbia rivers. The boundaries of the Pasco Basin are defined by anticlinal structures of basaltic rock. These structures are the Saddle Mountains to the north; the Umtanum Ridge, Yakima Ridge, and Rattlesnake Hills to the west; and the Rattlesnake Hills and a series of doubly plunging anticlines merging with the Horse Heaven Hills to the south.

The terrain within the Pasco Basin is relatively flat. Its surface features were formed by catastrophic floods and have undergone little modification since, with the exception of more recently formed sand dunes (DOE 1986a).

The elevations of the alluvial plain that covers much of the site vary from 105 meters (345 feet) above mean sea level in the southeast corner to 245 meters (803 feet) in the northwest. The 200-Area plateau in the central part of the site varies in elevation from 190 to 245 meters (623 to 803 feet).

The major geologic units of the Hanford Site are (in ascending order): subbasalt rocks (inferred to be sedimentary and volcanoclastic rocks), the Columbia River Basalt Group with intercalated sediments of the Ellensburg formation, the Ringold formation, the Plio-Pleistocene unit, and the Hanford formation. Locally, sand and silt exist as surface material. A generalized stratigraphic column is shown in Figure 4.3.

Knowledge of the subbasalt rocks is limited to studies of exposures along the margin of the Columbia Plateau and to a few deep boreholes drilled in the interior of the plateau (DOE 1988). No subbasalt rocks are exposed within the central interior of the Columbia Plateau, including the Pasco Basin. Interpretation of data from wells drilled in the 1980s by Shell Oil Company in the northwestern Columbia Plateau indicates that in the central part of the Columbia Plateau the Columbia River Basalt Group is underlain predominantly by Tertiary continental sediments (Campbell 1989).

The Hanford formation lies on the eroded surface of the Plio-Pleistocene unit, on the Ringold formation, or locally on the basalt bedrock. The Hanford formation consists of catastrophic flood sediments that were deposited when ice dams in western Montana and northern Idaho were breached and massive volumes of water spilled abruptly across eastern and central Washington. The floods scoured the land surface, locally eroding the Ringold formation, the basalts, and sedimentary interbeds, leaving a network of buried channels crossing the Pasco Basin (Tallman et al. 1979). Thick sequences of sediments were deposited by several episodes of flooding with the last major flood sequence dated at about 13,000 years before the present (Myers et al. 1979).

Figure 4-3. A generalized stratigraphic column of the major geologic units of the Hanford Site.

4.6.1.2 Structure. The Columbia Plateau is tectonically a part of the

North American continental plate, and is separated from the Pacific and Juan de Fuca oceanic plates to the west by the Cascade Range, Puget-Willamette Lowland, and Coast Range geologic provinces. It is bounded on the north by the Okanogan Highlands, on the east by the Northern Rocky Mountains and Idaho Batholith, and on the south by the High Lava plains and Snake River plain. The tectonic history of the Columbia Plateau has included the eruption of the continental flood basalts of the Columbia River Basalt Group during the period of about 17 to 6 million years before present, as well as volcanic activity in the Cascade Range to the west (DOE 1988).

Structurally, the Columbia Plateau can be divided into three informal

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a. Quaternary- A geologic period beginning approximately two million years ago and extending to the present.

b. Tephra- A collective term for all clastic materials ejected from a volcano and transported through air.

subprovinces: the Palouse, Blue Mountains, and Yakima Fold Belt. All but the easternmost part of the Pasco Basin is within the Yakima Fold Belt structural subprovince (DOE 1988). The Yakima Fold Belt contains four major structural elements: the Yakima Folds, Cle Elum-Wallula disturbed zone, Hog Ranch-Naneum anticline, and northwest-trending wrench faults.

The Yakima Folds are a series of continuous, narrow, asymmetric anticlines that have wavelengths between about 5 and 30 kilometers (3 to 19 miles) and amplitudes commonly less than 1 kilometers (less than 0.6 miles). The anticlinal ridges are separated by broad synclines or basins. The Yakima Folds are believed to have developed under generally north-south compression, but the origin and timing of the deformation along the fold structures are not well known (DOE 1988). Thrust or high-angle reverse faults are often found along both limbs of the anticlines, with the strike of the fault planes parallel or subparallel to the axis of the anticlines. Very little direct field evidence indicates quaternary movement along these anticlinal ridges. One of three cases of suspected Quaternary faulting is along the central Gable Mountain fault in the Pasco Basin. This fault is on the Hanford Site. It was considered by the NRC to be presumed capable, but not demonstrated to be capable for licensing purposes of the WNP plant.

The Cle Elum-Wallula disturbed zone is the central part of a larger topographic alignment called the Olympic-Wallowa lineament that extends from the northwestern edge of the Olympic Mountains to the northern edge of the Wallowa Mountains in Oregon. The Cle Elum-Wallula disturbed zone is a narrow zone about 10 kilometers (6 miles) wide that transects the Yakima Fold Belt and has been divided informally into three structural domains: a broad zone of deflected or anomalous fold and fault trends extending south of Cle Elum, Washington to Rattlesnake Mountain; a narrow belt of aligned domes and doubly plunging anticlines (called The Rattles) extending from Rattlesnake Mountain to Wallula Gap; and the Wallula fault zone, extending from Wallula Gap to the Blue Mountains. Evidence for quaternary deformation has been reported for 14 localities in or directly associated with the Cle Elum-Wallula disturbed zone. However, no evidence has been reported northwest of the Finley Quarry location (DOE 1988), about 60 kilometers (36 miles) southeast of the approximate center of the Hanford Site.

The Hog Ranch-Naneum Ridge anticline is a broad structural arch that extends from southwest of Wenatchee, Washington to the Yakima Ridge. This feature defines part of the northwestern boundary of the Pasco Basin, but little is known about the structural geology of this portion of the feature, and the southern extent of the feature is not known.

Northwest-trending wrench (strike-slip) faults have been mapped west of 120yW longitude in the Columbia Plateau (DOE 1988). The mean strike direction of the dextral wrench faults is 320y, but northeast-trending sinistral wrench faults that strike 013y are less numerous. These structures are not known to exist in the central Columbia Plateau.

Most known faults within the Hanford area are associated with anticlinal fold axes, are thrust or reverse faults although normal faults do exist, and were probably formed concurrently with the folding (DOE 1988). Existing known faults within the Hanford area include wrench (strike-slip) faults as long as 3 kilometers (1.9 miles) on Gable Mountain and the Rattlesnake-Wallula alignment, which has been interpreted as a right-lateral strike-slip fault. The faults in Central Gable Mountain are considered NRC capable by the U.S. Nuclear Regulatory Commission criteria (10 CFR 100) in that they have slightly displaced the Hanford formation gravels, but their relatively short lengths give them low seismic potential. No seismicity has been observed on or near Gable Mountain. The Rattlesnake-Wallula alignment is interpreted as possibly being capable, in part because of lack of any distinct evidence to the contrary and because this structure continues along the northwest trend of faults that appear active at Wallula Gap, some 56 kilometers (35 miles) southeast of the central part of the Hanford Site (DOE 1988).

Strike-slip faults have not been observed crosscutting the Pasco Basin. Anticlinal ridges that bound the Pasco Basin have been mapped in detail, and except for some component of dextral movement on the Rattlesnake-Wallula alignment, no strike-slip faults similar to those in the western Yakima Fold Belt have been observed (DOE 1988). Wrench (strike-slip) faults have been observed along the ridges at boundaries between geometrically coherent segments of the structures, as in the Saddle Mountains, but these faults are confined to the individual structures and formed as different geometries developed in the fold. Similar type faults have been mapped on Gable Mountain and studied in detail. These features are also interpreted as wrench (stike-slip) faults that are a response to folding.

In general, for structures within the Hanford Site area, the greatest deformation occurs in the hinge area of the anticlinal ridges and decreases with distance from that area; that is, the greatest amount of tectonic jointing and faulting occurs in the hinge zone and decreases toward the gently dipping limbs. The faults usually exhibit low dips with small displacements, may be confined to the layer in which they occur, and die out to no recognizable displacement in short lateral distances (DOE 1988).

4.6.1.3 Soils. Hajek (1966) lists and describes 15 different soil types on

the Hanford Site. The soil types vary from sand to silty and sandy loam. Various classifications, including land use, are also given in Hajek (1966). The proposed SNF facility site does not contain prime or unique farmland.

Section 4.8.2.1 (Groundwater Hydrology) provides a full discussion on ranges of thickness of the various geological units/soil types across the Hanford Site (Figures 4-3 and 4-11). The surface Hanford Formation varies in thickness across the Hanford Site from approximately 15 to 100 meters (49 to 328 feet) thick (Figure 4-11). The Middle Ringold Formation varies from 10 to 100 meters (32 to 328 feet) thick. The Lower Ringold and Basal Ringold Formations only extend eastward from the western boundary of the Hanford Site approximately 11 kilometers (6.8 miles). The former is rather uniform in thickness at 20 meters (65 feet), while the latter demonstrates a maximum thickness of 40 meters (131 feet) at the far western boundary of the Hanford Site. Groundwater movement within these layers is also discussed in Section 4.8.2.1.

There is a rather thick vadose zone on the Hanford Site. However, conclusions drawn from studies conducted at several locations vary from no downward percolation of precipitation on the 200 Area Plateau, where soil texture is varied and layered with depth (all moisture penetrating the soil is removed by evaporation) to observations of downward water movement below the root zone in the 300 Area, where soils are coarse textured and where precipitation was above normal (DOE 1987).

4.6.2 Mineral Resources

Sand, gravel, and cobble deposits are ubiquitous components of the soils over the Columbia Basin in general and the Hanford Site in particular: therefore, any possible economic impact to these resources resulting from the siting of the proposed SNF facility or an access road would be considered negligible. However, because gravel pits occur near the proposed SNF facility site, from which the DOE has been extracting gravel for many uses on the Hanford Site, these deposits could have economic value.

4.6.3 Seismic and Volcanic Hazards

The following discussion briefly summarizes seismic and volcanic hazards on the Hanford Site. A more detailed discussion of seismic and volcanic hazards can be found in Cushing (1992).

4.6.3.1 Seismic Hazards. The historic record of earthquakes in the Pacific

Northwest dates from about 1840. The early part of this record is based on newspaper reports of structural damage and human perception of the shaking, as classified by the Modified Mercalli Intensity scale, and is probably incomplete because the region was sparsely populated. Seismograph networks did not start providing earthquake locations and magnitudes of earthquakes in the Pacific Northwest until about 1960. A comprehensive network of seismic stations that provides accurate locating information for most earthquakes larger than magnitude 2.5 was installed in eastern Washington in 1969. A summary of the seismicity of the Pacific Northwest, a detailed review of the seismicity in the Columbia Plateau region and the Hanford Site, and a description of the seismic networks used to collect the data are provided in DOE (1988).

Large earthquakes (magnitude greater than 7 on the Richter scale) in the Pacific Northwest have occurred in the vicinity of Puget Sound, Washington, and near the Rocky Mountains in eastern Idaho and western Montana. A large earthquake of uncertain location occurred in north-central Washington in 1872. This event had an estimated maximum ranging from VIII to IX and an estimated magnitude of approximately 7. The distribution of intensities suggests a location within a broad region between Lake Chelan, Washington and the British Columbia border. Figure 4-4 shows the known faults occurring in the region.

Figure 4.4. Map of the Columbia Basin region showing the known faults. Seismicity of the Columbia Plateau, as determined by the rate of earthquakes per area and the historical magnitude of these events, is relatively low when compared to other regions of the Pacific Northwest, the Puget Sound area and

western Montana/eastern Idaho. Figure 4-5 shows the locations of all earthquakes that occurred in the Columbia Plateau before 1969 with IV or larger and with a magnitude of 3 or larger. Figure 4-6 shows the locations of all earthquakes that occurred from 1969 to 1986 with magnitudes of 3 or greater. The largest known earthquake in the Columbia Plateau occurred in 1936 around Milton-Freewater, Oregon. This earthquake had a magnitude of 5.75 and a maximum of VII, and was followed by a number of aftershocks that indicate a northeast-trending fault plane. Other earthquakes with magnitudes of 5 or larger and/or intensities of VI are located along the boundaries of the Columbia Plateau in a cluster near Lake Chelan extending into the northern Cascade Range; in northern Idaho and Washington; and along the boundary between the western Columbia Plateau and the Cascade Range. Three VI earthquakes have occurred within the Columbia Plateau, including one in the Milton-Freewater region in 1921, one near Yakima, Washington in 1892, and one near Umatilla, Oregon in 1893.

In the central portion of the Columbia Plateau, the largest earthquakes near the Hanford Site are two that occurred in 1918 and 1973. These two earthquakes had magnitudes of 4.4 and an intensity of V and were located north of the Hanford Site. Earthquakes often occur in spatial and temporal clusters in the central Columbia Plateau, and are termed earthquake swarms. The region north and east of the Hanford Site is a region of concentrated earthquake swarm activity, but earthquake swarms have also occurred in several locations within the Hanford Site.

Earthquakes in a swarm tend to gradually increase and decay in frequency of events, and usually no one outstanding large event is present within the sequence. These earthquake swarms occur at shallow depths, with 75 percent of the events located at depths less than 4 kilometers (2.5 miles). Each earthquake swarm typically lasts several weeks to months, consists of several to 100 or more earthquakes, and is clustered in an area 5 to 10 kilometers (3 to 6 miles) in lateral dimension. Often, the longest dimension of the swarm area is elongated in an east-west direction. However, detailed locations of swarm earthquakes indicate that the events occur on fault planes of variable orientation, and not on a single, throughgoing fault plane.

Earthquakes in the central Columbia Plateau also occur to depths of about 30 kilometers (18 miles). These deeper earthquakes are less clustered and occur more often as single, isolated events. Based on seismic refraction surveys in the region, the shallow earthquake swarms are occurring in the Columbia River Basalts, and the deeper earthquakes are occurring in crustal layers below the basalts.

Figure 4-5. Historical seismicity of the Columbia Plateau and surrounding areas. All earthquakes between 1850 and 1969 with a Modified Mercalli Intensity of IV or larger with a magnitude of 3 or greater are shown (Rohay 1989).

Figure 4-6. Recent seismicity of the Columbia Plateau and surrounding areas as measured by seismographs. All earthquakes between 1969 and 1986 with a Modified Mercalli Intensity of IV or larger with a magnitude of 3 or greater are shown (Rohay 1989).

The spatial pattern of seismicity in the central Columbia Plateau suggests an association of the shallow swarm activity with the east-west-oriented Saddle Mountains anticline. However, this association is complex, and the earthquakes do not delineate a throughgoing fault plane that would be consistent with the faulting observed on this structure.

Earthquake mechanisms in the central Columbia Plateau generally indicate reverse faulting on east-west planes, consistent with a north-south-directed maximum compressive stress and with the formation of the east-west-oriented anticlinal fold of the Yakima Fold Belt (Rohay 1987). However, earthquake focal mechanisms indicate faulting on a variety of fault plane orientations.

Earthquake focal mechanisms along the western margin of the Columbia Plateau also indicate north-south compression, but here the minimum compressive stress is oriented east-west, resulting in strike-slip faulting (Rohay 1987). Geologic studies indicate an increased component of strike-slip faulting in the western portion of the Yakima Fold Belt. Earthquake focal mechanisms in the Milton-Freewater region to the southeast indicate a different stress field, one with maximum compression directed east-west instead of north-south.

Estimates for the earthquake potential of structures and zones in the central Columbia Plateau have been developed during the licensing of nuclear power plants at the Hanford Site. In reviewing the operating license application for a Washington Public Power Supply System project, the Nuclear Regulatory Commission (NRC 1982) concluded that four earthquake sources should be considered for the purpose of seismic design: the Rattlesnake-Wallula alignment, Gable Mountain, a floating earthquake in the tectonic province, and a swarm area.

For the Rattlesnake-Wallula alignment, which passes along the southwest boundary of the Hanford Site, the estimated maximum magnitude is 6.5, and for Gable Mountain, an east- west structure that passes through the northern portion of the Hanford Site, the estimated maximum magnitude is 5.0. These estimates were based upon the inferred sense of slip, the fault length, or the fault area. The floating earthquake for the tectonic province was developed from the largest event located in the Columbia Plateau, the magnitude 5.75

Milton-Freewater earthquake. The maximum swarm earthquake for the purpose of seismic design was a magnitude 4.0 event. Figures 4-7 through 4-11 demonstrate the ranges of frequencies versus the acceleration across the Hanford Site (Geomatrix Consultants, Inc. 1993).

The seismic design is based upon a Safe-Shutdown Earthquake of 0.25 gravity (g; acceleration). The potential earthquake risk associated with the Gable Mountain structure dominated the risks associated with other potential sources that were considered. For DOE site comparison purposes, a maximum horizontal ground surface acceleration of 0.17-0.20g at the Hanford Site is estimated to result from an earthquake that could occur once every 2,000 years (DOE 1994c). The seismic hazard information presented in this EIS is for general seismic hazard comparisons across DOE sites. Potential seismic hazards for existing and new facilities could be evaluated on a facility specific basis consistent with DOE orders and standards and site specific procedures.

4.6.3.2 Volcanic Hazards. Several major volcanoes are located in the

Cascade Range west of the Hanford Site. The nearest volcano, Mount Adams, is about 165 kilometers (102 miles) from the Hanford Site, and the most active is Mount St. Helens, approximately 220 kilometers (136 miles) west-southwest from Hanford.

A period of renewed volcanic activity at Mount St. Helens began in March 1980 and climaxed in a major eruption on May 18, 1980. This eruption resulted in about 1 millimeter (0.039 inches) of ash fall over a 9-hour period at the Hanford Site, which was near the southern edge of the ash dispersal plume. Smaller eruptions of steam and ash occurred through October 1980, but none of these deposited measurable amounts of ash at the site. Because of their close proximity, the volcanic mountains of the Cascades are the principal volcanic hazard at Hanford.

The major concern is how ash fall might affect the operation of communications equipment and electronic devices, as well as the movement of truck and automobile traffic in and out the project site area.

4.7 Air Resources

This section addresses the general air resources at the Hanford Site and surrounding region. Included in this section are discussions on climate and meteorology, ambient air quality, and atmospheric dispersion.

Figure 4-7. Computed mean and 5th to 95th percentile hazard curves for the 200-West Area of the Hanford Site. Shown are results for peak horizontal acceleration and 5 percent-damped spectral acceleration at 0.3 and 2.0 seconds (Geomatrix Consultants, Inc. 1993).

Figure 4-8. Computed mean and 5th to 95th percentile hazard curves for the 200-East Area of the Hanford Site. Shown are results for peak horizontal acceleration and five percent-damped spectral acceleration at 0.3 and 2.0 seconds (Geomatrix Consultants, Inc. 1993).

Figure 4-9. Computed mean and 5th to 95th percentile hazard curves for the 300 Area of the Hanford Site. Shown are results for peak horizontal

acceleration and five percent-damped spectral acceleration at 0.3 and 2.0 seconds (Geomatrix Consultants, Inc. 1993).

Figure 4-10. Computed mean and 5th to 95th percentile hazard curves for the 400 Area of the Hanford Site. Shown are results for peak horizontal acceleration and five percent-damped spectral acceleration at 0.3 and 2.0 seconds (Geomatrix Consultants, Inc. 1993).

Figure 4-11. Computed mean and 5th to 95th percentile hazard curves for the 100-K Area of the Hanford Site. Shown are results for peak horizontal acceleration and five percent-damped spectral acceleration at 0.3 and 2.0 seconds (Geomatrix Consultants, Inc. 1993).

4.7.1 Climate and Meteorology

The climate of the Hanford Site, located in southcentral Washington

State, can be classified as mid-latitude semiarid or mid-latitude desert, depending on the climatological classification scheme used. Summers are warm and dry with abundant sunshine. Large diurnal temperature variations result from intense solar heating during the day and radiational cooling at night. Daytime high temperatures in June, July, and August periodically exceed 38yC (100yF). Winters are cool with occasional precipitation. Outbreaks of cold air associated with modified arctic air masses can reach the area and cause temperatures to drop below -18yC (0yF). Overcast skies and fog occur periodically (Stone et al. 1983).

Topographic features have a significant impact on the climate of the Hanford Site. All air masses that reach the region undergo some modification resulting from their passage over the complex topography of the Pacific Northwest. The climate of the region is strongly influenced by the Pacific Ocean and the Cascade Range to the west. The relatively low annual average rainfall of 16.1 centimeters (6.3 inches) at the Hanford Meteorological Station is caused largely by the rain shadow created by the Cascade Range. These mountains limit much of the maritime influence of the Pacific Ocean, resulting in a more continental-type climate than would exist if the mountains were not present. Maritime influences are experienced in the region during the passage of frontal systems and as a result of movement through gaps in the Cascade Range (such as the Columbia River Gorge).

The Rocky Mountains to the east and the north also influence the climate of the region. These mountains play a key role in protecting the region from the more severe winter storms and the extremely low temperatures associated with the modified arctic air masses that move southward through Canada. Local and regional topographical features, such as the Yakima Ridge and the Rattlesnake Hills, also impact meteorological conditions across the Hanford Site (Glantz and Perrault 1991). In particular, these features have a significant impact on wind directions, wind speeds, and precipitation levels.

Climatological data are collected for the Hanford Site at the Hanford Meteorological Station. The station is located between the 200-West and 200-East Areas and is in close proximity to the proposed project site. Data have been collected at this location since 1945 and are summarized in Stone et al. (1983). Beginning in the early 1980s, data have also been collected at a series of automated monitoring sites located throughout the Hanford Site and the surrounding region (Glantz et al. 1990). This Hanford Meteorological Monitoring Network is described in detail in Glantz and Islam (1988).

4.7.1.1 Wind. Prevailing wind directions on the 200-Area plateau are

from the northwest in all months of the year. Secondary maxima occur for southwesterly winds. Summaries of wind direction indicate that winds from the northwest quadrant occur most often during the winter and summer. During the spring and fall, the frequency of southwesterly winds increases with a corresponding decrease in northwest flow. Winds blowing from other directions (for instance, the northeast) display minimal variation from month to month. Monthly average wind speeds are lowest during the winter months, averaging 2.8 to 3.1 meters per second (6.2 to 6.8 miles per hour)--, and highest during the summer, averaging 3.9 to 4.4 meters per second (8.7 to 9.9 miles per hour). Summertime drainage winds are generally northwesterly and can frequently gust to 14 meters per second (31 miles per hour). A wind rose for the Hanford Site is shown in Figure 4-12.

4.7.1.2 Temperature and Humidity. Eight separate temperature

measurements are made at the 122-meter (400-foot) tower at the Hanford Meteorological Station. As of May 1987, temperatures are also measured at the 2-meter (6.6-foot) level on the twenty-two 9.1-meter (30-foot) towers located on and around the Hanford Site. The three 61-meter (200-foot) towers have temperature-measuring instrumentation at the 2-, 9.8-, and 61-meter (6.6-, 32-, and 200-foot) levels. The temperature data from the 9.1- and 61-meter (30- and 200-foot) towers are telemetered to the Hanford Meteorological Station.

Diurnal and monthly averages and extremes of temperature, dew point, and humidity are contained in Stone et al. (1983). Ranges of daily maximum and minimum temperatures vary from normal maxima of 2yC (36yF) in early January to 35yC (95yF) in late July. On the average, 55 days during the summer months have maximum temperatures greater than or equal to 32yC (90yF), and 13 days have maxima greater than or equal to 38yC (100yF). From mid-November through mid-March, minimum temperatures average less than or equal to 0yC (32yF), with the minima in early January averaging -6yC (21yF). During the winter, on average, four days have minimum temperatures less than or equal to -18yC (0yF); however, only about one winter in two experiences such temperatures. The record maximum temperature is 46yC (115yF), and the record minimum temperature is -33yC (-27yF). For the period 1912 through 1980, the average monthly temperatures ranged from a low of -1.5yC (29yF) in January to a high of 24.7yC (77yF)

Figure 4-12. Wind rose for the Hanford Site using data collected from January 1982 to December 1989 (Glantz et al. 1990). The direction of each of the petals of the wind rose indicates the wind direction, and the petal length is representative of the percentage of time the wind was from that direction. Petal thickness represents measured wind-speed category. The velocity categories, from thinnest line (near the center of the rose) to thickest line (near the edge of the rose), are 0.4-1.3 meters per second (1-3 miles per hour), 1.8-3.1 meters per second (4-7 miles per hour), 3.6-5.4 meters per second (8-12 miles per hour), 5.8-8.0 meters per second (13-18 miles per hour), 8.5-10.7 meters per second (19-24 miles per hour), 11.2-13.9 meters per second (25-31 miles per hour), respectively.

in July. During the winter, the highest monthly average temperature at the Hanford Meteorological Station was 7yC (45yF), and the record lowest was -5.9yC (21yF), both occurring during February. During the summer, the record highest monthly average temperature was 27.9yC (82yF, in July), and the record lowest was 17.2yC (63yF, in June).

Relative humidity/dew point temperature measurements are made at the Hanford Meteorological Station and at the three 61-meter (200-foot) tower locations. The annual average relative humidity at the Hanford Meteorological Station is 54 percent. It is highest during the winter months, averaging about 75 percent, and lowest during the summer, averaging about 35 percent. Wet bulb temperatures greater than 24yC (75yF) had not been observed at the Hanford Meteorological Station before 1975; however, on July 8, 9, and 10 of that year, seven hourly observations indicated wet bulb temperatures greater than or equal to 24yC (75yF).

Fog reduces the visibility to 6 miles during an average of 42 days each year and to less than 0.25 mile during an average of 25 days per year.

4.7.1.3 Precipitation. The average annual precipitation at the Hanford

Meteorological Station is 16.1 centimeters (6.3 inches). Most of the precipitation occurs during the winter with nearly half of the annual amount occurring in the months of November through February. Days with greater then 1.3 centimeters (0.5 inches) precipitation occur less than 1 percent of the year. A rainfall intensity of at least 1.3 centimeters per hour (0.5 inches per hour) persisting for 1 hour has only a 10 percent probability of occurring in any given year. A rainfall intensity of at least 2.5 centimeters per hour (1 inch per hour) has only a 0.2 percent probability of occurring in any given year. Winter monthly average snowfall ranges from 0.8 centimeters (0.3 inches) in March to 13.5 centimeters (5.3 inches) in January. The record snowfall of 53 centimeters (21 inches) occurred in December 1992. During the months of December, January, and February, snowfall accounts for about 38 percent of all precipitation.

4.7.1.4 Severe Weather. A discussion of severe weather may include a

variety of meteorological events, including, but not limited to, severe winds, dust and blowing dust, hail, fog, glaze, ash falls, extreme temperatures, temperature inversions, and blowing and drifting snow. These are described in detail in Stone et al. (1983). For many facilities, estimates of severe winds are of particular concern. The Hanford Meteorological Station's climatological summary and the National Severe Storms Forecast Center's database list only 24 separate tornado occurrences within 160 kilometers (100 miles) of the Hanford Site from 1916 to 1992 (Cushing 1992). Only one of these tornadoes was observed within the boundaries of the Hanford Site (on its extreme western edge), and no damage resulted. The estimated probability of a tornado striking a point at Hanford is 9.6 x 10-6 per year (Cushing 1992). Because tornadoes are infrequent and generally small in the Pacific Northwest (and hurricanes do not reach this area), risks from severe winds are generally associated with thunderstorms or the passage of strong cold fronts. The greatest peak wind gust recorded at 15 meters (50 feet) above ground level at the Hanford Meteorology Station was 36 meters per second (80 miles per hour). Projections on the return periods for peak gusts exceeding a specified speed are given in Stone et al. (1983). Extrapolations based on 35 years of observations indicate a return period of about 200 years for a peak gust in excess of 40 meters per second (90 miles per hour) at 15 meters (50 feet) above ground level.

4.7.1.5 Atmospheric Stability. The transport and diffusion of airborne

pollutants is dependent on the horizontal and vertical distribution of temperature, moisture, and wind velocity in the atmosphere. Greater amounts of turbulence or mixing in an atmospheric layer lead to greater rates of diffusion. The highest rates of diffusion are found in thermally unstable layers, moderate rates of diffusion are found in neutral layers, and the lowest rates of diffusion are found in thermally stable layers. There are a number of methods for estimating the "stability" of the atmosphere. Using a method based on the vertical temperature gradient (NRC 1980) and measurements made at the Hanford Meteorology Station, thermally unstable conditions are estimated to occur an average of about 25% of the time, neutral conditions about 31% of the time, and thermally stable conditions about 44% of the time. Detailed information on Hanford's atmospheric stability and associated wind conditions are presented in Glantz et al. (1990).

4.7.2 Nonradiological Air Quality

National ambient air quality standards (NAAQS) have been set by the EPA as mandated in the 1970 Clean Air Act. Ambient air is that portion of the atmosphere, external to buildings, to which the general public has access. For DOE facilities, this is interpreted to mean the site boundary or other publicly accessible location, e.g., highways on the site. The standards define levels of air quality that are necessary, with an adequate margin of safety, to protect the public health (primary standards) and the public welfare (secondary standards). Standards exist for sulfur oxides (measured as sulfur dioxide), nitrogen dioxide, carbon monoxide, particles with an aerodynamic diameter less than or equal to 10 micrometers (PM10), lead, and ozone. The standards specify the maximum pollutant concentrations and frequencies of occurrence that are allowed for specific averaging periods (that is, the concentration of carbon monoxide when averaged over 1 hour is allowed to exceed 40 milligrams per cubic meter only once per year). The averaging periods vary from 1 hour to 1 year, depending on the pollutant.

In addition to ambient air quality standards, the EPA has established standards for the Prevention of Significant Deterioration (PSD) of air quality. The PSD standards differ from the NAAQS in that the NAAQS provide maximum allowable concentrations of pollutants, while PSDs provide maximum allowable increases in concentrations of pollutants for areas already in compliance with NAAQS. Prevention of Significant Deterioration standards are expressed as allowable increments in atmospheric concentrations of specific pollutants (nitrogen dioxide, sulfur dioxide, and PM10) (40 CFR 52.21, "Prevention of Significant Deterioration of Air Quality"). Different PSD standards exist for Class I areas (where degradation of ambient air quality is to be severely restricted), and Class II areas (where moderate degradation of air quality is allowed) (Wark and Warner 1981). The PSD standards are presented in Table 4.7-1. The nitrogen oxide emissions from the Plutonium and Uranium Recovery through EXtraction (PUREX) plant and the Uranium Oxide (UO3) plant are permitted by the EPA under the PSD program (Cushing 1992).

State and local governments have the authority to impose standards for ambient air quality that are stricter than the national standards. Washington State has established more stringent standards for sulfur dioxide. In addition, Washington has established standards for volatile organic compounds, arsenic, fluoride, total suspended particulates, and other pollutants that are not covered by national standards. The state standards for carbon monoxide and nitrogen dioxide are identical to the national standards. At the local level, the Benton-Franklin Counties Clean Air Authority has the authority to establish more stringent air standards, but has not done so. Table 4.7-2 summarizes Washington State standards, and background and ambient concentrations for Hanford.

4.7.2.1 Background Air Quality. The closest Class I areas to the

Hanford Site are Mount Rainier National Park, located approximately 160 kilometers (100 miles) west of the site; Goat Rocks Wilderness Area, located approximately 145 kilometers (90 miles) west of the site;

Table 4.7-1. Maximum allowable increases for prevention of significant deterioration of air quality[a].

Pollutant	Averaging Time	Class I	Class II
Particulate matter[b] (PM10)			
	annual	4	17
	24 hours	8	30
Sulfur dioxide			
	annual	2	20
	24 hours	5	91
	3 hours	25	512
Nitrogen dioxide			
	annual	2.5	25

a. Source: 40 CFR 52.21.
b. Particulate matter is defined as suspended particulates with an aerodynamic diameter less than 10 micrometers.

Table 4.7-2. Washington State ambient air quality standards applicable to Hanford, maximum background concentration, background as percent of standard, ambient baseline (1995), ambient baseline as percent of standard, and ambient baseline plus background as percent of standard (standards and concentrations are in microgram per cubic meter).

Pollutant	Averaging Time	Washington State Standard	Maximum Background Concentration	Background as Percent of Standard	Ambient Baseline (effective 1995)	Ambient Baseline as percent of standard	Ambient Baseline and Background as percent of standard
Sulfur dioxide	annual	52	0.5	1	2	4	5
	24 hour	260	6	2	19	7	10
	1 hour	1,018	49	5	127	12	17
	1 hour	655[b]	49	7	127	19	27
Particulate matter							
TSP[c]	annual	60	56	93	0	0	93
	24 hour	150	356	237	6	4	241
PM	annual	50[d]	26[e]	52	0	0	52
	24 hour	150	596[e]	397	3	2	397
Carbon monoxide	8 hour	10,000	6,500	65	3	0	65
	1 hour	40,000	11,800	30	10	0	30
Ozone	1 hour	235	not estimated	not estimated	not estimated	not estimated	not estimated
Nitrogen dioxide	annual	100	36	36	3	3	39
Lead	annual	1.5	not estimated	not estimated	not estimated	not estimated	not estimated

a. Source: Air Quality Impact Analysis in Support of the New Production Reactor Environmental Impact Statement.
b. The standard is not to be exceeded more than twice in any seven consecutive days.
c. The TSP standards have been replaced by the PM10 standards, but the former are

serving as interim standards.

d. Arithmetic mean of the quarterly arithmetic means for the four calendar quarters of the year.

e. Maximum concentrations were measured in 1992 at Columbia Center in Kennewick. This value includes background concentration and site concentrations.

Mount Adams Wilderness Area, located approximately 150 kilometers (95 miles) southwest of the site; and Alpine Lakes Wilderness Area, located approximately 175 kilometers (110 miles) northwest of the site.

Air quality in the Hanford region is well within the state and federal standards for criteria pollutants, except that short-term particulate concentrations occasionally exceed the 24-hour PM10 standard (Table 4.7-2). Concentrations of toxic chemicals, as listed in 40 CFR Part 60.01, are not available for the Hanford Site. Because the highest concentrations of airborne particulate material are generally a result of natural events, the area has not been designated non-attainment(a) with respect to the PM10 standard. However, the local clean air authority is currently completing discussions with EPA and the Department of Ecology regarding plans to conduct additional evaluations of potential sources and mitigation measures, if any, that might be implemented to reduce the short-term particulate loading.

Particulate concentrations can reach relatively high levels in eastern Washington because of exceptional natural events (dust storms, volcanic eruptions, and large brushfires) that occur in the region. Washington ambient air quality standards do not consider rural fugitive dust from exceptional natural events when estimating the maximum background concentrations of particulate in the area east of the Cascade Mountain crest. Similarly, the EPA also exempts the rural fugitive dust component of background concentrations when considering permit applications and enforcement of air quality standards (Cushing 1992).

4.7.2.2 Source Emissions. Emissions inventories for permitted pollution

sources in Benton, Franklin, and Walla Walla counties are routinely compiled by the Tri-County Air Pollution Control Board. The annual emission rates for stationary sources within the Hanford Site boundaries were reported to the Washington State Department of Ecology by the U.S. Department of Energy and are provided in Table 4.7-3.

The EPA's ISC/ST model was used for baseline modeling of stationary sources projected to be in operation in 1995 (Hadley 1991). Projected baseline conditions (presented in Table 4.7-2) are estimated to be well below any current national or state standards (Hadley 1991).

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a. An attainment area is an area where measured concentrations of a pollutant are below the primary and secondary National Ambient Quality Standards (NAAQS).

Table 4.7-3. Emission rates (tons per year) for stationary emission sources within the Hanford Site for 1992a.

Source	Operation (hours per year)	TSP	PM10	Sulfur Dioxide	Nitrogen Oxides	Volatile Organic Compounds	Carbon Monoxide
300 Area Boiler #2	6384	9	8	110	22	0	2
300 Area Boiler #6	8760	4	3	48	10	0	1
200-East Boiler	8760	3	1	200	58	1	49
200-West Boiler	8760	4	1	260	75	1	62
200-East, 200-West Fugitive Coal	8760	107	54	0	0	0	0
300 Area Temporary Boiler	8760	9	8	120	24	0	2
Fugitive Emissions, 200-E	8760	1	0	0	0	0	0

a. Source: Cushing in preparation.

4.7.2.3 Nonradiological Air Quality Monitoring.

4.7.2.3.1 Onsite Monitoring-The most recent monitoring data

available were obtained in 1992. Details of the monitoring program are described in Woodruff and Hanf (1993). The only onsite air quality monitoring conducted during 1991 was for nitrogen oxides. These oxides were sampled at three locations on the Hanford Site with a bubbler assembly operated to collect 24-hour integrated samples. The highest annual average concentration was <0.006 parts per million by volume, well below the applicable federal and Washington State annual ambient standard of 0.05 parts per million by volume (Cushing 1992). Monitoring of total suspended solids was discontinued in early 1988 when the Basalt Waste Isolation Project, for which those measurements were required, was concluded. In 1992 sampling was done at Rattlesnake Springs (near the southwestern edge of the site) for polychlorinated biphenyls (PCBs) and volatile organic compounds. Levels of PCB concentrations were found to be <0.27 to <0.29 nanogram per cubic meter (Woodruff and Hanf 1993). These values are well below the EPA limit of 1 nanogram per cubic meter. The volatile organic compounds tested for were halogenated alkanes and alkenes, benzene, and alkylbenzenes. All volatile organic compound concentrations were well below the occupational maximum allowable concentrations of air contaminants.

4.7.2.3.2 Offsite Monitoring-During the past 10 years, carbon

monoxide, sulfur dioxide, and nitrogen dioxide have been monitored periodically in communities and commercial areas southeast of Hanford. These urban measurements are typically used to estimate the maximum background pollutant concentrations for the Hanford Site because of a lack of specific onsite monitoring. Because these measurements were made in the vicinity of local sources of pollution, they will overestimate maximum background concentrations for the Hanford Site or at the site boundaries.

The only offsite monitoring in the vicinity of the Hanford Site in 1990 was conducted by the Washington Department of Ecology for particulates (WDOE 1991). Total suspended particulate (TSP) monitoring at Tri-Cities locations was discontinued in early 1989. Monitoring at the remaining two locations, Sunnyside and Wallula, continued during 1990. The annual geometric means of measurements at Sunnyside and Wallula for 1990 were 71 micrograms per cubic meter and 80 micrograms per cubic meter, respectively; both of these values exceeded the Washington State annual standard of 60 micrograms per cubic meter. The Washington State 24-hour standard, 150 micrograms per cubic meter, was exceeded six times during the year at Sunnyside and seven times at Wallula (Cushing 1992).

Particulate matter (PM10) was also monitored at three locations: Columbia Center in Kennewick, Walla Walla Fire Station, and Wallula. During 1992, the 24-hour PM10 standard adopted by Washington State, 150 micrograms per cubic meter, was exceeded two times at the Columbia Center monitoring location. The maximum 24-hour concentration at Columbia Center was 596 micrograms per cubic meter. The maximum 24-hour concentration at the Walla Walla Fire Station was 67 micrograms per cubic meter. The maximum 24-hour concentration at Wallula was 124 micrograms per cubic meter. None of the sites exceeded the annual primary standard, 50 micrograms per cubic meter (Cushing in preparation). As noted previously, the Benton-Franklin counties area has not been designated nonattainment with respect to PM10 standards because the particulate concentrations result from natural events.

4.7.2.4 Summary of Nonradiological Air Quality. The Hanford Site is

currently considered an attainment area for criteria pollutants. However, PM10 concentrations are high enough that the designation may change. There are no Class I areas close enough to the site to be affected by emissions at Hanford. Carbon monoxide concentrations are at 65 percent of the allowed concentration (for an eight-hour averaging time). Current PM10 concentrations are at 52 percent of the allowed ambient standard. Nitrogen dioxide concentrations are at 36 percent of the allowed values. All other pollutants, for which ambient air quality standards exist, are below 25 percent of the allowed values.

4.7.3 Radiological Air Quality

Radionuclide emissions to the atmosphere from the Hanford Site have been steadily decreasing over the last few years as site operations have changed emphasis from the historical mission of materials production and processing to energy and waste management research. During 1992, all operations at the Hanford Site released less than 100 Ci of radionuclides to the atmosphere, most of which consisted of tritium and noble gases (Woodruff and Hanf 1993). Of that total, fission and activation products accounted for less than 0.036 Ci, uranium isotopes accounted for less than 1 x 10-6 Ci, and transuranics contributed less than 0.005 Ci. These releases resulted in a dose to the maximally exposed offsite resident of less than 0.005 mrem, which is several orders of magnitude less than the current EPA standard of 10 mrem per year for DOE facilities.

Ambient air monitoring for radionuclides consisted of sampling at 42 onsite and offsite locations during 1992. Total concentrations of alpha- and beta-emitting radionuclides at the site perimeter were indistinguishable from those at distant locations that are unaffected by Hanford emissions. Concentrations of two specific radionuclides (tritium and iodine-129) were elevated relative to background; however, their contribution to the total airborne activity was small.

4.8 Water Resources

4.8.1 Surface Water

4.8.1.1 Surface Water Hydrology. The Pasco Basin occupies about

4900 square kilometers (1900 square miles) and is located centrally within the Columbia Basin. Elevations within the Pasco Basin are generally lower than other parts of the plateau, and surface drainage enters it from other basins. Within the Pasco Basin, the Columbia River is joined by three major tributaries: the Yakima River, the Snake River, and the Walla-Walla River.

The Hanford Site occupies approximately one-third of the land area within the Pasco Basin. Primary surface-water features associated with the Hanford Site are the Columbia and Yakima rivers. Several surface ponds and ditches are present, and they are generally associated with fuel- and waste-processing activities. Several small spring-streams occur on the Arid Land Ecology site on the western side of the Hanford Site.

A network of dams and multipurpose water resources projects is located along the course of the Columbia River. The principal dams are shown in Figure 4-13. Storage behind Grand Coulee Dam, combined with storage upstream in Canada, totals 3.1 x 1010 cubic meters (1.1 x 1012 cubic feet) of usable storage to regulate the Columbia River for power, flood control, and irrigation of land within the Columbia Basin project.

Figure 4-13. Locations of major surface water resources and principal dams within the Columbia Plateau.

Approximately two-thirds of the surface runoff, if there were any from Hanford, would drain directly into the Columbia River along the Hanford Reach, which extends from the upstream end of Lake Wallula to the Priest Rapids Dam. One-third of the surface runoff would drain into the Yakima River, which flows into the Columbia River below the Hanford Site. The flow has been inventoried and described in detail by the U.S. Army Corps of Engineers (DOE 1986a). Flow along this reach is controlled by the Priest Rapids Dam. Several drains and intakes are also present along this reach. These include irrigation outfalls from the Columbia Basin Irrigation Project and Hanford Site intakes for the onsite water export system.

Recorded flow rates of the Columbia River have ranged from 4500 to 18,000 cubic meters per second (~158,900 to 635,600 cubic feet per second) during the runoff in spring and early summer, to 1000 to 4500 cubic meters per second (35,300 to 158,900 cubic feet per second) during the low flow period of late summer and winter. The average annual Columbia River flow in the Hanford Reach, based on records from 65 years, is about 3400 cubic meters per second (120,100 cubic feet per second) (DOE 1988). A minimum flow of about 1020 cubic meters per second (35,000 cubic feet per second) is maintained along the Hanford Site. Normal river elevations within the site range from 120 meters (394 feet) above mean sea level where the river enters the Hanford Site near Vernita to 104 meters (341 feet) where it leaves the site near the 300-Area.

The Yakima River, near the southern portion of the Hanford Site, has a low annual flow compared to the Columbia River. For 57 years of record, the average annual flow of the Yakima River is about 104 cubic meters per second (3673 cubic feet per second) with monthly maximum and minimum flows of 490 cubic meters per second (17,305 cubic feet per second) and 4.6 cubic meters per second (162 cubic feet per second), respectively.

Cold Creek and its tributary, Dry Creek, are ephemeral streams within the Yakima River drainage system along the southern boundary of the Hanford Site. Both streams drain areas to the west of the Hanford Site and cross the southwestern part of the site toward the Yakima River.

Surface flow, when it occurs, infiltrates and disappears into the surface sediments in the western part of the Hanford Site (refer to subsection 4.6.1.3 for a discussion of soil types and moisture percolation). Rattlesnake Springs, located on the western part of the site, forms a small surface stream that flows for about 3 kilometers (1.8 miles) before disappearing into the ground. Approximately one-third of the Hanford Site is drained by the Yakima River system.

Total estimated precipitation over the Pasco Basin is about 9 x 106 cubic meters (318 x 106 cubic feet) annually, averaging less than 20 centimeters per year (~8 inches per year). Mean annual runoff from the basin is estimated to be less than 3.1 x 107 cubic meters per year (109 x 107 cubic feet per year), or approximately 3 percent of the total precipitation. The basin-wide runoff coefficient is zero for all practical purposes. The remaining precipitation is assumed to be lost through evapotranspiration, with a small component (perhaps less than 1 percent) recharging the groundwater system (DOE 1988).

Water use in the Pasco Basin is primarily from surface diversion with groundwater diversions accounting for less than 10 percent of the use. A listing of surface water diversions, volumes, types of usage, and the populations served is given in DOE (1988). Industrial and agricultural usage represent about 32 percent and 58 percent, respectively, and municipal use about 9 percent. The Hanford Site uses about 81 percent of the water withdrawn for industrial purposes. However, because of the N Reactor shutdown and considering the data in DOE (1988), these percentages now approximate 13 percent for industrial, 75 percent for agricultural, and 12 percent for municipal use, with the Hanford Site accounting for about 41 percent of the water withdrawn for industrial use.

Approximately 50 percent of the wells in the Pasco Basin are for domestic use and are generally shallow (less than 150 meters [500 feet]). Agricultural wells, used for irrigation and stock supply, make up the second-largest category of well use, about 24 percent for the Pasco Basin. Industrial users account for only about 3 percent of the wells (DOE 1988).

Most of the water used by the Hanford Site is withdrawn from the Columbia River. The principal users of groundwater within the Hanford Site are the Fast Test Flux Facility, with a 1988 use of 142,000 cubic meters (5.0 x 106 cubic feet) from two wells in the unconfined aquifer, and the PNL Observatory, with a water supply from a spring on the side of Rattlesnake Mountain.

Regional effects of water-use activities are apparent in some areas where the local water tables or potentiometric levels have declined because of withdrawals from wells. In other areas, water levels in the shallow aquifers have risen because of artificial recharge mechanisms, such as excessive application of imported irrigation water or impoundment of streams. Wastewater ponds on the Hanford Site have artificially recharged the unconfined aquifer below the 200-East and 200-West Areas. The increase in water table elevations was most rapid from 1950 to 1960, and apparently had nearly reached equilibrium between the unconfined aquifer and the recharge during 1970 to 1980 when only small increases in water table elevations occurred. Wastewater discharges from the 200-West Area were significantly reduced in 1984 (DOE 1988), with an accompanying decline in water table elevations.

4.8.1.2 Flood Plains. Large Columbia River floods have occurred in the past (DOE 1987), but the likelihood of recurrence of large-scale flooding has been reduced by the construction of several flood control/water storage dams upstream of the site. Major floods on the Columbia River are typically the result of rapid melting of the winter snowpack over a wide area augmented by above-normal precipitation. The maximum historical flood on record occurred June 7, 1894, with a peak discharge at the Hanford Site of 21,000 cubic meters per second (742,000 cubic feet per second). The flood plain associated with the 1894 flood is shown in Figure 4-14. The largest recent flood took place in 1948 with an observed peak discharge of 20,000 cubic meters per second (706,280 cubic feet per second) at the Hanford Site. The probability of flooding at the magnitude of the 1894 and 1948 floods has been greatly reduced because of upstream regulation by dams.

The Federal Emergency Management Agency has not prepared flood plain maps for the Hanford Reach of the Columbia River because that agency prepares maps only for developing areas (a criteria that specifically excludes the Hanford Reach).

Evaluation of flood potential is conducted in part through the concept of the probable maximum flood, determined from the upper limit of precipitation falling on a drainage area and other hydrologic factors, such as antecedent moisture conditions, snowmelt, and tributary conditions, that could result in maximum runoff. The probable maximum flood for the Columbia River below Priest Rapids Dam has been calculated to be 40,000 cubic meters per second (1.4 million cubic feet per second) and is greater than the 500-year flood. The flood plain associated with the probable maximum flood is shown in Figure 4-15. This flood would inundate parts of the 100-Areas located adjacent to the Columbia River, but the central portion of the Hanford Site where the SNF facility would be located would remain unaffected (DOE 1986a).

Figure 4-14. Flood area during the 1894 flood.

Figure 4-15. Flood area for the probable maximum flood.

The U.S. Army Corps of Engineers (1989) has derived the Standard Project Flood with both regulated and unregulated peak discharges given for the Columbia River below Priest Rapids Dam. Frequency curves for both natural (unregulated) and regulated peak discharges are also given for the same portion of the Columbia River. The regulated Standard Project Flood for this part of the river is given as 15,200 cubic meters per second (54,000 cubic feet per second) and the 100-year regulated flood as 12,400 cubic meters per second (440,000 cubic feet per second). No maps for the flooded areas are provided.

Potential dam failures on the Columbia River have been evaluated (DOE 1986a; ERDA 1976). Upstream failures could arise from a number of causes, with the magnitude of the resulting flood depending on the degree of breaching at the dam. The U.S. Army Corps of Engineers evaluated a number of scenarios on the effects of failures of Grand Coulee Dam, assuming flow conditions of the order of 11,000 cubic meters per second (400,000 cubic feet per second). For purposes of emergency planning, they hypothesized that 25 percent and 50 percent breaches, the instantaneous disappearance of 25 percent or 50 percent of the center section of the dam, would result from the detonation of nuclear explosives in sabotage or war. The discharge or floodwave resulting from such an instantaneous 50 percent breach at the outfall of the Grand Coulee Dam was determined to be 600,000 cubic meters per second (21 million cubic feet per second). In addition to the areas inundated by the probable maximum flood (see Figure 4-15), the remainder of the 100 Areas, the 300 Area, and nearly all of Richland, Washington, would be flooded (DOE 1986a; ERDA 1976). Determinations were not made for failures of dams upstream, for associated failures downstream of Grand Coulee, or for breaches greater than 50 percent of Grand Coulee for two principal reasons: the 50 percent scenario was believed to represent the largest realistically conceivable flow resulting from either a natural or human-induced breach (DOE 1986a); that is, it was hard to imagine that a structure as large as the Grand Coulee Dam would be 100 percent destroyed instantaneously. It was also assumed that such a scenario as the 50 percent breach would only occur as the result of direct explosive detonation, not because of a natural event such as an earthquake. Even a 50 percent breach under these conditions would indicate an emergency situation where other overriding major concerns might be present.

The possibility of a landslide resulting in river blockage and flooding along the Columbia River has also been examined for an area bordering the east side of the river upstream from the city of Richland (DOE 1986a). The possible landslide area considered was the 75-meter- (250-foot-) high bluff generally known as White Bluffs. Calculations were made for an 8 x 105 cubic meter (1 x 106 cubic yards) landslide volume with a concurrent flood flow of 17,000 cubic meters per second (600,000 cubic feet per second) (a 200-year flood) resulting in a flood wave crest elevation of 122 meter (400 foot) above mean sea level. Areas inundated upstream from such a landslide event would be similar to those shown in Figure 4-15.

A flood risk analysis of Cold Creek was conducted in 1980 as part of the characterization of a basaltic geologic repository for high-level radioactive waste. Such design work is usually done to the criteria Standard Project Flood or Probable Maximum Flood rather than the worst case or 100-year flood scenario. Therefore, in lieu of 100- and 500-year floodplain studies, a probable maximum flood evaluation was made for a reference repository location directly west of the 200-East Area and encompassing the 200-West Area (Skaggs and Walters 1981). Figure 4-16 shows the extent of this evaluation.

4.8.1.3 Surface Water Quality.

4.8.1.3.1 Water Quality of the Columbia River-The Department of

Ecology classifies the Columbia River as Class A (excellent) between Grand Coulee Dam and the mouth of the river near Astoria, Oregon (DOE 1986a). The Hanford Reach of the Columbia River is the last free-flowing portion of the river in the United States.

Pacific Northwest Laboratory conducts routine monitoring of the Columbia River for both radiological and nonradiological water quality parameters. A yearly summary of results has been published since 1973 (Woodruff and Hanf 1993). Numerous other water quality studies have been conducted on the Columbia River relative to the impact of the Hanford Site during the past 37 years. Currently, eight outfalls are covered by National Pollutant Discharge Elimination System (NPDES) permits at the Hanford Site: two at the 100-K Area, five at the 100-N Area, and one at the 300 Area. These discharge locations are monitored for various measures of water quality, including nonradioactive and radioactive pollutants. The dose from any radionuclide releases is estimated for the Annual Environmental Monitoring Report for the Hanford Site. In 1993, monitored liquid discharges resulted in a dose of 0.012 mrem to the downstream maximally exposed individuals (Dirkes et al. 1994). Permit applications have been submitted to EPA Region 10 for three new facilities (outfalls) planned for the 100 and 300 Areas. These new facilities include a treatment facility for process wastewater (1325-N), a filter backwash/ash sluicing wastewater disposal facility (315/384), and the 300 Area Treated Effluent Disposal Facility.

Figure 4-16. Extent of probable maximum flood in Cold Creek area.

Radiological monitoring shows low levels of radionuclides in samples of Columbia River water. Tritium, iodine-129, and uranium are found in somewhat higher concentrations downstream of the Hanford Site than upstream (Woodruff and Hanf 1993), but well below concentration guidelines established by DOE and EPA drinking-water standards (Table 4.8-1). Cobalt-60 and iodine-131 were not consistently found in measurable quantities during 1989 in samples of Columbia River water from Priest Rapids Dam, the 300-Area water intake, or the Richland city pumphouse (Woodruff and Hanf 1991). In 1989, the average annual strontium-90 concentrations were essentially the same at Priest Rapids Dam (upstream of the Hanford Site) and the Richland Pumphouse (Woodruff and Hanf 1991).

Nonradiological water quality parameters measured during 1989 were similar to those reported in previous years and were within Washington State Water Quality Standards (Woodruff and Hanf 1991). Under Federal Water Pollution Control Act Amendments of 1972 (as amended by the Clean Water Act of 1972) the NPDES can regulate permits issued to DOE-RL for discharges of nonradioactive effluents made to the Columbia River.

Table 4.8-1. Annual average concentrations of radionuclides in Columbia River water during 1992.

Radionuclides	Water concentrations (pCi/L) Upstream concentration (Priest Rapids Dam)	Downstream concentration (Richland Pumphouse)	EDA drinking water standard
H-3	50	101	20,000
Sr-90	0.09	0.09	8.0
Uranium	0.42	0.51	NA
Tc-99	0.10	0.21	900
I-129	<2.3 x 10-5	<1.4 x 10-4	1

a. Data taken from Woodruff and Hanf (1993).

4.8.1.3.2 Water Quality of the Unconfined Aquifer-As part of the continuing environmental

monitoring program, groundwater monitoring reports have been issued since 1956 and are now published in the Hanford Site Environmental Report, which is issued by calendar year. The shallow, unconfined aquifer in the Pasco Basin and on the Hanford Site contains waters of a dilute (less than or approximately 350 milligrams per liter total dissolved solids) calcium bicarbonate chemical type. Other principal constituents include sulfate, silica, magnesium, and nitrate. Variability in chemical composition exists within the unconfined aquifer in part because of natural variation in the composition of the aquifer material; in part because of agricultural and irrigation practices north, east, and west of the Hanford Site; and, on the Hanford Site, in part because of liquid waste disposal.

Graham et al. (1981) compared analyses of unconfined aquifer water samples taken by the U.S. Geological Survey in the Pasco Basin, but off the Hanford Site, with samples taken by PNL and the USGS on the Hanford Site for the years 1974 through 1979. In general, Hanford Site groundwater analyses showed higher levels of chemical constituents and temperatures than were reflected in the analyses of offsite samples.

Elevated levels of some constituents in the Hanford groundwater result from releases of various liquid wastes from disposal facilities, primarily in the 100 Areas (formerly the site of production reactor operations) and 200 Areas (formerly the spent fuel reprocessing and defense materials production site). Mobile contaminants, such as tritium and nitrate, from the 200 Areas are present in a groundwater plume that extends across the southeastern quadrant of the Hanford Site and enters the Columbia River along a broad front north of the 300 Area. Contaminants having lower mobility are generally confined to smaller localized plumes in the vicinity of the disposal facilities and migrate more slowly toward the Columbia River (Dirkes et al. 1994). Some longer-lived radionuclides, such as strontium-90 and cesium-137, have reached the groundwater, primarily through liquid waste disposal cribs. Minor quantities of longer-lived radionuclides have also reached the water table via a failed groundwater monitoring well casing and through reverse well injection, a disposal practice that was discontinued at Hanford in 1947 (Smith 1980).

Of the contaminants found in groundwater, several radionuclides and nonradioactive chemicals were present in concentrations that exceeded EPA drinking water standards or DOE Derived Concentration Guides (DCG) in 1993 (Dirkes et al. 1994). These quantities are used as a relative measure of contamination, although with one exception, groundwater beneath the site is not used for human consumption or food production. Groundwater utilized for drinking at the FFTF visitor center contains above-background quantities of tritium and iodine-129 from the 200 Area plume; however, these levels are well below the EPA drinking water standards. There is little opportunity for contaminated groundwater to migrate to locations where members of the public might utilize it directly for domestic purposes or irrigation. Groundwater in the unconfined aquifer beneath the Hanford Site is relatively isolated, and generally flows toward the north and east where it discharges to the Columbia River. Normal hydraulic gradients within the unconfined aquifer beneath the Hanford Site prevent southward migration of groundwater toward populated areas near Richland, and recharge to the Columbia River from aquifers in Franklin County to the north and east prevents radionuclides in the Columbia River from migrating to groundwater across the river from Hanford.

Groundwater monitoring at the 100 Areas detected concentrations of cobalt-60, strontium-90, antimony-125, and uranium that were above the EPA drinking water standards. Tritium concentrations exceeded both the EPA drinking water standard and the DOE DCG at one sample well in each of the 100-N and 100-K Areas. In 200 Area wells, cobalt-60, technetium-99, iodine-129, cesium-137, uranium, and plutonium were occasionally found in concentrations that exceeded the EPA drinking water standard; tritium and strontium-90 exceeded both the EPA drinking water standard and the DOE DCG in some locations. Only uranium exceeded the EPA drinking water standard in 300 Area wells, a result of liquid waste disposal at former fuel fabrication facilities.

Three nonradiological constituents - nitrate, chromium, and trichloroethylene - exceeded EPA drinking water standards in both 100 and 200 Area groundwater. In addition to those constituents, some 200 Area wells exceeded EPA drinking water standards for cyanide, fluoride, carbon tetrachloride, and chloroform. Only trichloroethylene was found above the drinking water limits in the 300 Area.

The occurrence and consequences of leaks from waste storage tanks and of radioactive materials in soils have been described elsewhere (ERDA 1975). These occurrences have not resulted, and are not expected to result, in radiation exposure to the public (ERDA 1975; DOE 1987). Leakage from the 105-KE fuel storage basin results in groundwater contamination with several radionuclides, as noted previously. The more mobile radionuclides reach the Columbia River via springs near the 100-K Area, although radionuclides in the springs were below the EPA drinking water standard in 1993 (Dirkes et al. 1994).

Radioactive and nonradioactive effluents are discharged to the environment from Westinghouse Hanford Company facilities in the 200 Area (Cooney et al. 1988). These effluents, in general, are discharged to the soil column. Cooling water represents by far the largest volume of potentially radioactive liquid effluent. Additional treatment systems for these effluents are being designed and installed pursuant to the schedule set forth in the Hanford Federal Facility Agreement and Consent Order, which was jointly issued by DOE, EPA, and the Washington Department of Ecology in May 1989. Under the provisions of the Comprehensive Environmental Response Compensation and Liability Act, remedial investigations/feasibility studies will be conducted for groundwater operable units at Hanford.

Springs are common on basalt ridges surrounding the Pasco Basin. Geochemically, spring waters are of a calcium or sodium bicarbonate type with low dissolved solids (approximately 200 to 400 milligrams per liter) (DOE 1986a). Compositionally these waters are similar to shallow local groundwaters (unconfined aquifer and upper Saddle Mountains basalt). However, they are readily distinguishable from waters of the lower Saddle Mountains (Mabton interbed) and the Wanapum and Grande Ronde basalts, which are of sodium bicarbonate to sodium chloride bicarbonate (or sodium chloride sulfate) type. Currently, no evidence suggests these spring waters contain any significant component of deeper groundwater.

4.8.1.3.3 Water Quality of the Confined Aquifer-Areal and stratigraphic changes in

groundwater chemistry characterize basalt groundwaters beneath the Hanford Site (Graham et al. 1981). The stratigraphic position of these changes is believed to delineate flow-system boundaries and to identify chemical evolution taking place along groundwater flow paths. Using these data, some potential mixing of groundwaters has also been located; however, the rate of mixing is unknown. According to Woodruff and Hanf (1993), no evidence of contamination was observed in the groundwater of the confined aquifer on Rattlesnake Ridge. Groundwater in one well in this aquifer contained 8,800 micrograms of nitrate per liter in 1992. The well was located near an erosional window in the confining basalt flow. In another well, tritium levels were elevated (maximum of 7,830 picocuries per liter) in 1992. In the same well, elevated levels of iodine-129 (0.15 picocuries per liter) were observed in 1992.

4.8.2 Groundwater

4.8.2.1 Groundwater Hydrology. The regional geohydrologic setting of the Pasco Basin is based on the stratigraphic framework consisting of numerous Miocene tholeiitic flood basalts of the Columbia River Basalt group; relatively minor amounts of intercalated fluvial and volcanoclastic Ellensburg Formation sediments; and fluvial, lacustrine, and glaciofluvial suprabasalt sediments. The vertical order of the geological units from the surface downward is Hanford formation, Middle Ringold Formation, Lower Ringold Formation, Basal Ringold Formation, and bedrock, e.g., basalt. Figure 4-3 illustrates the stratigraphic layering of the hydrogeologic units underlying the Hanford Site, and Figure 4-17 shows the order of the geological units. The surface Hanford formation varies in thickness across the Hanford Site from approximately 15 to 100 meters (49 to 328 feet) thick (Figure 4-17). The Middle Ringold Formation varies from 10 to 110 meters (33 to 361 feet) thick. The Lower Ringold and Basal Ringold Formations extend eastward from the western boundary of the site approximately 1.1 kilometers (6.8 miles). The Lower Ringold Formation is rather uniform in thickness at 20 meters (66 feet), while the Basal Ringold Formation demonstrates a maximum thickness of 40 meters (131 feet) at the far western boundary of the site (interpolated from Woodruff and Hanf 1993). Lateral groundwater movement is known to occur within a shallow, unconfined aquifer consisting of fluvial and lacustrine sediments lying on top of the basalts, and within deeper confined-to-semiconfined aquifers consisting of basalt flow tops, flow bottom zones, and sedimentary interbeds (DOE 1988). These deeper aquifers are intercalated with aquitards consisting of basalt flow interiors. Vertical flow and leakage between geohydrologic units is inferred and estimated from water level or potentiometric surface data but is not quantified, and direct measurements are not available (DOE 1988).

Figure 4-17. Geologic cross section of the Hanford Site (modified from Tallman et al. 1979).

The multiaquifer system within the Pasco Basin has been conceptualized as consisting of four geohydrologic units: (1) the Grande Ronde Basalt; (2) Wanapum Basalt; (3) Saddle Mountain Basalt; and (4) suprabasalt Hanford and Ringold Formation sediments. Geohydrologic units older than the Grande Ronde Basalt are probably of minor importance to the regional hydrologic dynamics and system.

The Grande Ronde Basalt is the most voluminous and widely spread formation within the Columbia River Basalt group and has a thickness of at least 2745 meters (9000 feet). The Grande Ronde Basalt geohydrologic unit is composed of the Grande Ronde Basalt and minor intercalated sediments equivalent to or part of the Ellensburg Formation (DOE 1988). More than 50 flows of Grande Ronde Basalt underlie the Pasco Basin, but little is known of the lower 2200 to 2500 meters of this geohydrologic unit. This unit is a confined-to-semiconfined flow system that is recharged along the margins of the Columbia Plateau where the unit is at or close to the land surface, and by surface-water and groundwater inflow from lands adjoining the plateau. Vertical movement into and out of the unit is known to occur. Groundwater within the unit in the eastern Pasco Basin is believed to be derived from groundwater inflow from the east and northeast.

The Wanapum Basalt geohydrologic unit consists of basalt flows of the Wanapum Basalt intercalated with minor and discontinuous sedimentary interbeds of the Ellensburg Formation or equivalent sediments. In the Pasco Basin, the Wanapum Basalt consists of three members, each consisting of multiple flows. The geohydrologic unit underlies the entire Pasco Basin and has a maximum thickness of 370 meters (1215 feet). Groundwater within the Wanapum Basalt geohydrologic unit is confined to semiconfined. Recharge is believed to occur from precipitation where the Wanapum Basalt is not overlain by great thicknesses of younger basalt, leakage from adjoining formations, and surface-water and groundwater inflow from lands adjoining the plateau. Local recharge is derived from irrigation. Within the Pasco Basin, recharge occurs along the anticlinal ridges to the north and west, with recharge in the eastern basin being from groundwater inflow from the east and northeast (DOE 1988). Interbasin transfer and vertical leakage are also believed to contribute to the recharge.

The Saddle Mountains Basalt geohydrologic unit is composed of the youngest formation of the Columbia River Basalt Group and several thick sedimentary beds of the Ellensburg Formation or equivalent sediments that comprise up to 25 percent of the unit. Within the Pasco Basin, the Saddle Mountains Basalt contains seven members, each with one or more flows. This geohydrologic unit underlies most of the Pasco Basin, attaining a thickness of about 290 meters (950 feet), but is absent along the northwest part of the basin and along some anticlinal ridges. Groundwater in the Saddle Mountains geohydrologic unit is confined to semiconfined, with recharge and discharge believed to be local (DOE 1988).

The rock materials that overlie the basalts in the structural and topographic basins within the Columbia Plateau generally consist of Miocene-Pliocene sediments, volcanics, Pleistocene sediments (including those from catastrophic flooding), and Holocene sediments consisting mainly of alluvium and eolian deposits. The suprabasalt geohydrologic unit (referred to as the Hanford/Ringold unit) consists principally of the Miocene-Pliocene Ringold Formation stream, lake, and alluvial materials, and the Pleistocene catastrophic flood deposits informally called the Hanford formation. Groundwater within the suprabasalt geohydrologic unit is generally unconfined, with recharge and discharge usually coincident with topographic highs and lows (DOE 1988). The Hanford/Ringold unit is essentially restricted to the Pasco Basin with principal recharge occurring along the periphery of the basin from precipitation and ephemeral streams.

Little if any natural recharge occurs within the Hanford Site, but artificial recharge occurs from liquid waste disposal activities (Woodruff and Hanf 1993). Recharge from irrigation occurs east and north of the Columbia River and in the synclinal valleys west of the Hanford Site. Upward leakage from lower aquifers into the unconfined aquifer is believed to occur in the northern and eastern sections of the Hanford Site. Groundwater discharge is primarily to the Columbia River.

Groundwater under the Hanford Site occurs under unconfined and confined conditions (Figure 4-17). The unconfined aquifer is contained within the glaciofluvial sands and gravels of the Hanford formation and within the Ringold Formation. It is dominated by the middle member of the Ringold Formation, consisting of sands and gravels with varying amounts of cementation. The bottom of the unconfined aquifer is the basalt surface or, in some areas, the clay zones of the Lower Ringold. A semiconfined aquifer occurs in areas where the coarse-grained Basal Ringold lies between the basalt and the fine-grained Lower Ringold. The confined aquifers consist of sedimentary interbeds and/or interflow zones that occur between dense basalt flows in the Columbia River Basalt Group. The main water-bearing portions of the interflow zones occur within a network of interconnecting vesicles and fractures of the flow tops or flow bottoms.

4.8.2.2 Vadose Zone Hydrology. Sources of natural recharge to the unconfined aquifer are rainfall and

runoff from the higher bordering elevations, water infiltrating from small ephemeral streams, and river water along influent reaches of the Yakima and Columbia rivers. In order to define the movement of water in the vadose zone, the movement of precipitation through the unsaturated (vadose) zone has been studied at several locations on the Hanford Site. Conclusions from these studies are varied depending on the location studied. Some investigators conclude that no downward percolation of precipitation occurs on the 200-Area

Plateau where soil texture is varied and is layered with depth, and that all moisture penetrating the soil is removed by evaporation. Others have observed downward water movement below the root zone in tests conducted near the 300 Area, where soils are coarse textured and precipitation was above normal (DOE 1987).

From the recharge areas to the west, the groundwater flows downgradient to the discharge areas, primarily along the Columbia River. This general west-to-east flow pattern is interrupted locally by the groundwater mounds in the 200 Areas. From the 200 Areas, a component of groundwater also flows to the north, between Gable Mountain and Gable Butte. These flow directions represent current conditions; the aquifer is dynamic, and responds to changes in natural and artificial recharge.

Local recharge to the shallow basalts is believed to result from infiltration of precipitation and runoff along the margins of the Pasco Basin. Regional recharge of the deep basalts is thought to result from interbasin groundwater movement originating northeast and northwest of the Pasco Basin in areas where the Wanapum and Grande Ronde Basalts crop out extensively (DOE 1986a). Groundwater discharge from the shallow basalt is probably to the overlying unconfined aquifer and the Columbia River. The discharge area(s) for the deep groundwaters is presently uncertain, but flow is believed to be generally southeastward with discharge speculated to be south of the Hanford Site (DOE 1986a).

4.8.3 Existing Radiological Conditions

This section relates to the hydrology of the Hanford Site in general and to the hydrology of the 200 Area specifically because it is the location of the proposed SNF facility.

4.8.3.1 Hydrology of the Hanford Site. Groundwater quality on the Hanford Site has been affected by

defense-related activities to produce nuclear materials. Due to the arid nature of the climate, natural recharge of the groundwater on the site is normally low. Artificial recharge has occurred in the past from the disposal of liquid waste associated with processing operations in the 100, 200, and 300 Areas that created mounds of water underlying discharge points. While most of the site does not have contaminated groundwater, large areas underlying the site do have elevated levels of both radiological and nonradiological constituents. The liquid effluents discharged into the ground have carried with them certain radionuclides and chemicals that move through the soil column at varying rates, eventually enter the groundwater, and form plumes of contamination (see Figure 5.54 in DOE 1992a).

Groundwater monitoring is conducted on an annual basis on the Hanford Site as part of the Hanford Ground-Water Environmental Surveillance Program and other monitoring programs to study the movement of plumes, groundwater quality, and the concentration of certain constituents as regulated by the EPA, the DOE, and Washington State. In 1992, several groundwater samples were taken from approximately 720 wells, of which 50 percent were sampled at least quarterly or more frequently. The remainder were sampled either once or twice. Figure 5.49 in DOE (1992a) illustrates the locations of these monitoring wells.

Results indicate that total alpha, total beta, tritium, cobalt-60, strontium-90, technetium-99, iodine-129, cesium-137, and uranium concentrations in wells in or near operating areas exceeded Drinking Water Standards (DWS) (see Tables C2 and C3 in Appendix C of DOE [1992a]). Concentrations of uranium in the 200-West Area, tritium in the general 200 Area, strontium-90 in the 100-N and 200-East Areas exceeded the Derived Concentration Guides (DCGs) [see Table C6 in Appendix C of DOE (1992b)]. Tritium continues to slowly migrate downgradient with the groundwater flow where it enters the Columbia River; 1 curie of tritium was discharged to the Columbia River from the 100 Areas in 1992 (Woodruff and Hanf 1993).

Nitrate concentrations also exceeded DWS at various locations in the 100, 200, and 300 Areas and at several 600 Area locations. Elevated concentrations were also detected for chromium, cyanide, carbon tetrachloride, chloroform, and trichloroethylene in various sample wells in the 100 and 200 Areas. For further information regarding groundwater quality on the Hanford Site, refer to DOE (1992b).

4.8.3.2 Hydrology of the 200 Areas. The unconfined aquifer beneath the Hanford Site is contained

within the Ringold Formation and the overlying Hanford formation. The unconfined aquifer is affected by wastewater disposed to surface and subsurface disposal sites. The depth to groundwater ranges from 55 to 95 meters (180 to 310 feet) on the 200 Area Plateau. The bottom of the unconfined aquifer is the uppermost basalt surface or, in some areas, the clays of the Lower Ringold Member. The thickness of the unconfined aquifer in the 200 Areas ranges from less than 15 to 61 meters (50 to 200 feet). Beneath the unconfined aquifer is a confined aquifer system consisting of sedimentary interbeds or interflow zones that occur between dense basalt flows or flow units.

The sources of natural recharge to the unconfined aquifer are rainfall from areas of high relief to the west of the Hanford Site and two ephemeral streams, Cold Creek and Dry Creek. From the areas of recharge, the groundwater flows downgradient and discharges into the Columbia River. This general flow pattern is modified by basalt outcrops and subcrops in the 200 Areas and by artificial recharge.

The unconfined aquifer beneath the 200 Areas receives artificial recharge from liquid disposal areas. Cooling water disposed to ponds has formed groundwater mounds beneath two former and one continuing high-volume disposal sites: U Pond in the 200-West Area, B Pond east of the 200-East Area, and Gable Mountain Pond north of the 200-East Area. The water table rose approximately 20 meters (65 feet) under U Pond and 9 meters (30 feet) under B Pond compared with pre-Hanford conditions (Newcomb et al. 1972). However, U Pond and Gable Mountain Pond have been eliminated and, with no further recharge from them, the water levels will decline over the coming years. U Pond was deactivated in 1984 and Gable Mountain Pond was decommissioned and backfilled in 1987. The volume of B Pond increased after the elimination of Gable Mountain Pond.

The dry nature (for example, climate, waste form, and depth to water) of the low-level burial ground and the limited natural surface recharge available from precipitation minimize the probability of leachate formation and migration from these facilities.

Additional characterization and enhanced groundwater monitoring of the 200 Areas are currently being conducted pursuant to requirements established under the Resources Conservation and Recovery Act. When complete, this work will supply additional information on the 200 Areas.

4.8.4 Water Rights

The Hanford Site, situated along the Columbia River and near the Yakima River, lies within a region traditionally concerned about water rights. Typical water uses in this region include cooling a commercial nuclear power plant, irrigation, and municipal and industrial uses. Cooling water was withdrawn from the Columbia River to cool the defense reactors at Hanford. The DOE continues to assert a federally reserved water withdrawal right with respect to its existing Hanford operations. Current activities use water withdrawn from the Columbia River under the Department's federally reserved water right.

4.9 Ecological Resources

The Hanford Site is a relatively large, undisturbed area (1450 square kilometers [~560 square miles]) of shrub-steppe that contains numerous plant and animal species adapted to the region's semiarid environment. The site consists of mostly undeveloped land with widely spaced clusters of industrial buildings located along the western shoreline of the Columbia River and at several locations in the interior of the site. The industrial buildings are interconnected by roads, railroads, and electrical transmission lines. The major facilities and activities occupy about 6 percent of the total available land area, and their impact on the surrounding ecosystems is minimal. Most of the Hanford Site has not experienced tillage or livestock grazing since the early 1940s. The Columbia River flows through the Hanford Site, and although the river flow is not directly impeded by artificial dams within the Hanford Site, the historical daily and seasonal water fluctuations have been changed by dams upstream and downstream of the site (Rickard and Watson 1985). The Columbia River and other water bodies on the Hanford Site provide habitat for aquatic organisms. The Columbia River is also accessible for public recreational use and commercial navigation.

Topography of the proposed SNF facility site is level to gently sloping to the northeast. Substrate on the subject area is primarily Burbank loamy sand intergraded with Rupert sand. The latter consists of broad, stabilized sand dunes. Several used and unused unpaved roads cross the project area (Figure 4-18) with resulting disturbance to the plant community. The subject area outside the disturbed area is primarily a mature stand of big sagebrush with an understory of cheatgrass, an alien weed species, and Sandberg's bluegrass (Figure 4-18); there are approximately 494 square kilometers (191 square miles) of this community on the Hanford site. Sagebrush-bitterbrush/cheatgrass comprises the second largest plant community. Cover of big sagebrush increases rapidly from 10-25 percent near Route 4 to 25-50 percent over the remainder of the site. Cover of cheatgrass and Sandberg's bluegrass is mostly uniform across the subject area at 25-50 percent and 10-20 percent, respectively.

4.9.1 Terrestrial Resources

4.9.1.1 Vegetation. The Hanford Site, located in southeastern Washington, has been botanically char-

acterized as a shrub-steppe. Because of the site's aridity, the productivity of both plants and animals is relatively low compared with other natural communities. In the early 1800s, the dominant plant in the area was big sagebrush with an understory of perennial bunchgrasses, especially Sandberg's bluegrass and bluebunch wheatgrass. With the advent of settlement that brought livestock grazing and crop raising, the natural vegetation mosaic was opened to a persistent invasion by alien annuals, especially cheatgrass. Today cheatgrass is the dominant plant on fields that were cultivated 50 years ago. Cheatgrass is also well established on rangelands at elevations less than 244 meters (800 feet) (Rickard and Rogers 1983). Wildfires in the area are common; the most recent extensive fire in 1984 significantly altered the shrub component of the vegetation. The dryland areas of the Hanford Site were treeless in the years before land settlement; however, for several decades before 1943, trees were planted and irrigated on most of the farms to provide windbreaks and shade. When the farms were abandoned in 1943, some of the trees died but others have persisted, presumably because their

Figure 4-18. Distribution of vegetation types on the Hanford Site.

roots are deep enough to

contact groundwater. Today these trees serve as nesting platforms for several species of birds, including hawks, owls, ravens, magpies, and great blue herons, and as night roosts for wintering bald eagles (Rickard and Watson 1985). The vegetation mosaic of the Hanford Site currently consists of 10 major kinds of plant communities:

1) thyme buckwheat/Sandberg's bluegrass
2) sagebrush/bluebunch wheatgrass
3) sagebrush/cheatgrass or sagebrush/Sandberg's bluegrass
4) sagebrush-bitterbrush/cheatgrass
5) greasewood/cheatgrass-saltgrass
6) winterfat/Sandberg's bluegrass
7) cheatgrass-tumble mustard
8) willow or riparian
9) spiny hopsage/Sandberg's bluegrass
10) sand dunes.

The dominant plant community on the proposed SNF site is sagebrush/Sandberg's bluegrass, with cheatgrass-tumble mustard occurring in the southern portion of the site. A table listing common plants on the Hanford Site can be found in Cushing (1992).

Almost 600 species of plants have been identified on the Hanford Site (Sackschewsky et al. 1992). The dominant plants on the 200 Area Plateau are big sagebrush, rabbitbrush, cheatgrass, and Sandberg's bluegrass, with cheatgrass providing half of the total plant cover. More than 100 species of plants have been identified in the 200 Area Plateau. Cheatgrass and Russian thistle, annuals introduced to the United States from Eurasia in the late 1800s, invade areas where the ground surface has been disturbed. Certain desert plants have roots that grow to depths approaching 10 meters (33 feet) (Napier 1982); however, root penetration to these depths has not been demonstrated for plants in the 200 Areas. Rabbitbrush roots have been found at a depth of 2.4 meters (8 feet) near the 200 Areas (Klepper et al. 1979). Mosses and lichens appear abundantly on the soil surface; lichens commonly grow on the shrub stems. The important desert shrubs, big sagebrush and bitterbrush, are widely spaced and usually provide less than 20 percent canopy cover. The important understory plants are grasses, especially cheatgrass, Sandberg's bluegrass, Indian ricegrass, June grass, and needle-and-thread grass.

As compared to other semiarid regions in North America, primary productivity is relatively low and the number of vascular plant species is also low. This situation is attributed to the low annual precipitation (16 centimeters [~6 inches]), the low water-holding capacity of the rooting substrate (sand), and the droughty summers and occasionally very cold winters.

Sagebrush and bitterbrush are easily killed by summer wildfires, but the grasses and other herbs are relatively resistant and usually recover in the first growing season after burning. Fire usually opens the community to wind erosion. The severity of erosion depends on the severity and areal extent of the fire. Hot fires incinerate entire shrubs and damage grass crowns. Less intensive fires leave dead stems standing, and recovery of herbs is prompt. The most recent and extensive wildfire occurred in the summer of 1984.

Bitterbrush shrubs provide browse for a resident herd of wild mule deer. Bitterbrush shrubs are slow to recolonize burned areas because invasion is by seeds. Bitterbrush does not sprout even when fire damage is relatively light.

Certain passerine birds (such as sage sparrow, sage thrasher, and loggerhead shrike) rely on sagebrush or bitterbrush for nesting. These birds are not expected to nest in places devoid of shrubs. Jackrabbits also appear to avoid burned areas without shrubs. Birds that nest on the ground in areas without shrubs included longbilled curlews, horned larks, Western meadowlarks, and burrowing owls.

An ecological inventory of the vegetation on the proposed SNF facility site revealed two primary vegetation types: burned and unburned sagebrush/cheatgrass. Two species predominated in the burned area: cheatgrass and tarweed fiddleneck; the unburned vegetation comprised mainly cheatgrass and big sagebrush. During the one-day survey, approximately 43 species were identified.

4.9.1.2 Insects. More than 300 species of terrestrial and aquatic insects have been found on the Hanford

Site. Grasshoppers and darkling beetles are among the more conspicuous groups and, together with other species, are important in the food web of the local birds and mammals. Most species of darkling beetles occur throughout the spring to fall period, although some species are present only during two or three months in the fall (Rogers and Rickard 1977). Grasshoppers are evident during the late spring to fall. Both beetles and grasshoppers are subject to wide annual variations in abundance.

4.9.1.3 Reptiles and Amphibians. Among amphibians and reptiles, 12 species are known to occur on the

Hanford Site (Fitzner and Gray 1991). The occurrence of these species is infrequent when compared with similar fauna of the southwestern United States. The side-blotched lizard is the most abundant reptile and can be found throughout the Hanford Site. Short-horned and sagebrush lizards are also common in selected habitats. The most common snakes are the gopher snake, the yellow-bellied racer, and the Pacific rattlesnake, all found throughout the Hanford Site. Striped whipsnakes and desert night snakes are rarely found, but some sightings have been recorded for the site. Toads and frogs are found near the permanent water bodies and along the Columbia River. Cushing (1992) contains a list of all the reptiles and amphibians occurring on the Hanford Site.

4.9.1.4 Birds. Fitzner and Gray (1991) and Landeen et al. (1992) have presented data on birds observed

on the Hanford Site. The horned lark and western meadowlark are the most abundant nesting birds in the shrub-steppe. A list of some of the more common birds present on the Hanford Site can be found in Cushing (1992).

4.9.1.4.1 Birds Inhabiting Terrestrial Habitats-The game birds inhabiting terrestrial

habitats at Hanford are the chukar, gray partridge, and mourning dove. The chukar and partridge are year-round residents, but mourning doves are migrants. Although a few doves overwinter in south-eastern Washington, most leave the area by the end of September. Mourning doves nest on the ground and in trees all across the Hanford Site. Chukars are most numerous in the Rattlesnake Hills, Yakima Ridge, Umtanum Ridge, Saddle Mountains, and Gable Mountain areas of the Hanford Site. A few birds also inhabit the 200-Area Plateau. Gray partridges are not as numerous as chukars, and their numbers also vary greatly from year to year. Sage grouse populations have declined on the Hanford Site since the 1940s, and it is probable there are no grouse nests on the site at this time. The nearest viable population is located on the U.S. Army's Yakima Training Center, located to the north and west of the Hanford Site.

In recent years, the number of nesting ferruginous hawks has increased, at least in part because the hawks have accepted steel powerline towers as nesting sites. Only about 50 pairs are believed to be nesting in Washington. Other raptors that nest on the Hanford Site are the prairie falcon, northern harrier, red-tailed hawk, Swainson's hawk, and kestrel. Burrowing owls, great horned owls, barn owls, and long-eared owls also nest on the site but in smaller numbers.

4.9.1.5 Mammals. Approximately 39 species of mammals have been identified on the Hanford Site (Fitzner

and Gray 1991), and a complete list can be found in Cushing (1992). The largest vertebrate predator inhabiting the Hanford Site is the coyote, which ranges all across the site. Coyotes have been a major cause of destruction of Canada goose nests on Columbia River islands, especially islands upstream from the abandoned Hanford townsite. Bobcats and badgers also inhabit the Hanford Site in low numbers.

Black-tailed jackrabbits are common on the Hanford Site, mostly associated with mature stands of sagebrush. Cottontails are also common but appear to be more closely associated with the buildings, debris piles, and equipment laydown areas associated with the onsite laboratory and industrial facilities.

Townsend's ground squirrels occur in colonies of various sizes scattered across the Hanford Site but marmots are scarce. The most abundant mammal inhabiting the site is the Great Basin pocket mouse. It occurs all across the Columbia River plain and on the slopes of the surrounding ridges. Other small mammals include the deer mouse, harvest mouse, grasshopper mouse, montane vole, vagrant shrew, and Merriam's shrew.

The Hanford Site has seven species of bats that are known to be or are potential inhabitants, arriving mostly as fall or winter migrants. The pallid bat frequents deserted buildings and is thought to be the most abundant of the various species. Other species include the hoary bat, silver-haired bat, California brown bat, little brown bat, Yuma brown bat, and Pacific western big-eared bat.

A herd of Rocky Mountain elk is present on the ALE Reserve. It is believed these animals immigrated to the reserve from the Cascade Mountains in the early 1970s. This herd had grown from approximately 6 animals in 1972 to 119 animals in the spring of 1992. Elk frequently move off the ALE Reserve to private lands located to the north and west, particularly during late spring, summer, and early fall. However, while the elk are on the Hanford Site, they restrict their activities to the ALE Reserve. Lack of water and the high level of human activity presumably restrict the elk from using other areas of the Hanford Site. Despite the arid climate and their unusual habitat, these elk appear to be very healthy; antler and body size for given age classes are among the highest recorded for this species (McCorquodale et al. 1989). In addition, reproductive output is also among the highest recorded for this species. Elk remain on the ALE Reserve because of the protection it provides from human disturbance.

Mule deer are found throughout the Hanford Site, although areas of highest concentrations are on the ALE Reserve and along the Columbia River. Deer populations on the Hanford Site appear to be relatively stable. The herd is characterized by a large proportion of very old animals (Eberhardt et al. 1982) and high fawn mortality. Islands in the Hanford Reach of the Columbia River are used extensively as fawning sites by the deer (Eberhardt et al. 1979) and thus are a very important habitat for this species. Hanford Site deer frequently move offsite and are killed by hunters on adjacent public and private lands (Eberhardt et al. 1984).

The ecological survey conducted on an area adjacent to the proposed SNF facility site recorded (by presence or sign) 12 bird, 7 mammal, and 3 reptile species.

4.9.2 Wetlands

Several habitats on the Hanford Site could be considered as wetlands. The largest wetland habitat is the riparian zone bordering the Columbia River. The extent of this zone varies, but it includes extensive stands of willows, grasses, various aquatic macrophytes, and other plants. The zone is extensively impacted by both seasonal water level fluctuations and daily variations related to power generation at Priest Rapids Dam immediately upstream from the site.

Other extensive areas of wetlands can be found within the Saddle Mountain National Wildlife Refuge and the Wahluke Wildlife Refuge Area. These two areas encompass all the lands extending from the north bank of the Columbia River northward to the site boundary and east of the Columbia River down to Ringold

Springs. Wetland habitat in these areas consists of fairly large ponds resulting from irrigation runoff. These ponds have extensive stands of cattails (Typha sp.) and other emergent aquatic vegetation surrounding the open water regions. They are extensively used as resting sites by waterfowl.

Some wetlands habitat exists in the riparian zones of some of the larger spring streams on the ALE Reserve. These areas are not extensive and usually amount to less than a hectare in size, although the riparian zone along Rattlesnake Springs is probably about 2 kilometers (1.2 miles) in length and consists of peachleaf willows, cattails, and other plants. No wetlands are on or in the vicinity of the proposed project site area.

4.9.3 Aquatic Resources

There are two types of natural aquatic habitats on the Hanford Site: one is the Columbia River, which flows along the northern and eastern edges of the Hanford Site, and the other is provided by the small spring-streams and seeps located mainly in the Rattlesnake Hills. Several artificial water bodies, both ponds and ditches, have been formed as a result of wastewater disposal practices associated with the operation of the reactors and separation facilities. These bodies of water are temporary and will vanish with cessation of activities, but while present, they form established aquatic ecosystems (except West Pond) complete with representative flora and fauna (Emery and McShane 1980). West Pond is created by a rise in the water table in the 200 Areas and is not fed by surface flow; thus, it is alkaline and has a greatly restricted complement of biota.

4.9.3.1 The Columbia River. The Columbia River is the dominant aquatic ecosystem on the Hanford Site

and supports a large, diverse community of plankton, benthic invertebrates, fish, and other communities. It is the fifth largest river in North America and has a total length of about 2000 kilometers (~1240 miles) from its origin in British Columbia to its mouth at the Pacific Ocean. The Columbia has been dammed both upstream and downstream from the Hanford Site, and the reach flowing through the area is the last free-flowing, but regulated, reach of the Columbia River in the United States. Plankton populations in the Hanford Reach are influenced by communities that develop in the reservoirs of upstream dams, particularly Priest Rapids Reservoir, and by manipulation of water levels below by dam operations in downstream reservoirs. Phytoplankton and zooplankton populations at Hanford are largely transient, flowing from one reservoir to another. Generally, insufficient time does not allow characteristic endemic groups of phytoplankton and zooplankton to develop in the Hanford Reach. No tributaries enter the Columbia during its passage through the Hanford Site. Gray and Dauble (1977) list 43 species of fish in the Hanford Reach of the Columbia River. Since 1977, the brown bullhead (Ictalurus nebulosus) has also been collected, bringing the total number of fish species identified in the Hanford Reach to 44. Of these species, the chinook salmon, sockeye salmon, coho salmon, and steelhead trout use the river as a migration route to and from upstream spawning areas and are of the greatest economic importance. Both the fall chinook salmon and steelhead trout also spawn in the Hanford Reach. The relative contribution of upper river bright stocks to fall chinook salmon runs in the Columbia River increased from about 24 percent of the total in the early 1980s to 50 percent to 60 percent of the total by 1988 (Dauble and Watson 1990). The destruction of other main-stream Columbia spawning grounds by dams has increased the relative importance of the Hanford Reach spawning (Watson 1970, 1973). Fish migrating from the Columbia River up the Snake River would not be expected to pass through the Hanford area because the confluence of the two rivers lies downstream from the Hanford Site.

4.9.3.2 Spring Streams. The small spring streams, such as Rattlesnake and Snively springs, contain diverse biotic communities and are extremely productive (Cushing and Wolf 1984). Dense blooms of watercress occur and are not lost until one of the major flash floods occurs. The aquatic insect production is fairly high as compared to that in mountain streams (Gaines 1987). The macrobenthic biota varies from site to site and is related to the proximity of colonizing insects and other factors.

4.9.4 Threatened, Endangered, and Sensitive Species

Threatened and endangered plants and animals identified on the Hanford Site, as listed by the federal government (50 CFR 17) and Washington (Washington Natural Heritage Program 1994), are shown in Table 4.9-1. No plants or mammals on the federal list of endangered and threatened wildlife and plants (50 CFR 17.11, 17.12) are known to occur on the Hanford Site. However, several species of both plants and animals are under consideration for formal listing by the federal government and Washington.

4.9.4.1 Plants. Four species of plants are included in the Washington listing. Columbia milk-vetch (Astragalus columbianus Barneby) and Hoover's desert parsley (Lomatium tuberosum) are listed as threatened, and Columbia yellowcress (Rorippa columbiae Suksd.) and northern wormwood (Artemisia campestris ssp. borealis var. wormskioldii) are designated as endangered. Columbia milk-vetch occurs on dry land benches along the Columbia River in the vicinity of Priest Rapids Dam, Midway, and Vernita. It also has been found on top of Umtanum Ridge and in Cold Creek Valley near the present vineyards. Hoover's desert parsley grows on steep talus slopes in the vicinity of Priest Rapids Dam, Midway, and Vernita. Yellowcress occurs in the wetted zone of the water's edge along the Columbia River. Northern wormwood is known to occur near Beverley and could inhabit the northern shoreline of the Columbia River across from the 100 Areas.

Table 4.9-1. Threatened (T) and endangered (E) species known or possibly occurring on the Hanford Site.

Common name	Scientific name	Federal	State
Plants			
Columbia milk-vetch	Astragalus columbianus		T
Columbia yellowcress	Rorippa columbiae		E
Hoover's desert parsley	Lomatium tuberosum		T
Northern wormwood	Artemisia campestris borealis var. wormskioldii		E
Birds			
Aleutian Canada goose	Branta canadensis leucopareia	T	E
Peregrine falcon	Falco peregrinus	E	E
Bald eagle	Haliaeetus leucocephalus	T	T
White pelican	Pelecanus erythrorhychos		E
Sandhill crane	Grus canadensis		E
Ferruginous hawk	Buteo regalis		T
Mammals			
Pygmy rabbit	Brachylagus idahoensis		T
Insects			
Oregon silverspot butterfly	Speyerra zerene hippolyta	T	T

4.9.4.2 Animals. The federal government lists the Aleutian Canada goose (Branta canadensis leucopareia) and the bald eagle (Haliaeetus leucocephalus) as threatened and the peregrine falcon (Falco peregrinus) as endangered. In addition to the peregrine falcon, Aleutian Canada goose, and bald eagle, Washington lists the white pelican (Pelecanus erythrorhynchos) and sandhill crane (Grus canadensis) as endangered and the ferruginous hawk (Buteo regalis) as threatened. The peregrine falcon is a casual migrant to the Hanford Site and does not nest here. The Oregon silverspot butterfly (Speyerra zerene hippolyta) has recently been classified as a threatened species by both the state and federal governments. The bald eagle is a regular winter resident and forages on dead salmon and waterfowl along the Columbia River; nesting attempts have been made on the Hanford Site, but those have not been successful to date.   does not nest on the Hanford Site. Increased use of power poles for nesting sites by the ferruginous hawk on the Hanford Site has been noted. Washington State Bald Eagle Protection Rules were issued in 1986 (WAC-232-12-292). These rules require DOE to prepare a management plan to mitigate eagle disturbance; this has been done by Fitzner and Weiss (DOE/RL 1994). The Endangered Species Act of 1973 also requires that Section 7 consultation be undertaken when any action is taken that may jeopardize the existence of, destroy, or adversely modify habitat of the bald eagle or other endangered species.

Table 4.9-2 lists the designated candidate species that are under consideration for possible addition to the threatened or endangered list. Table 4.9-3 lists the plant species that are of concern in the state of Washington and are presently listed as sensitive or are in one of three monitor groups (Washington Natural Heritage Program 1994).

Sagebrush habitat is considered priority habitat by Washington because of its relative scarcity in the state and its requirement as nesting/breeding habitat by loggerhead shrikes (federal and state candidate species), sage sparrows (state candidate), burrowing owls (state candidate), pygmy rabbits (federal candidate and state threatened), sage thrashers (state candidate), western sage grouse (federal and state candidate), and sagebrush voles (state monitored). Although the last five species were not discovered during the present survey of the proposed SNF site, the habitat should be considered potentially suitable for their use. Pygmy rabbits and western sage grouse have only rarely been seen on the Hanford Site, and then primarily in upland regions. Loggerhead shrikes have been seen frequently on the proposed SNF facility site and are known to select tall big sagebrush as nest sites (Poole 1992). Although this species begins migration at the beginning of August (Poole 1992), one individual was observed during the present survey of the proposed SNF site. However, no nests were located. Ground squirrel burrows used by burrowing owls and owl pellets were observed during the present survey of the proposed SNF site. Numerous sage sparrows were also observed on the proposed SNF site. Pygmy rabbits would not have been observed during this survey because they are primarily crepuscular and nocturnal and may have already begun hibernation. However, this species is not known from lowland portions of the Hanford Site. The closest known ferruginous hawk (federal candidate and state threatened species) nest is approximately 8.9 kilometers (5.3 miles) northwest of the subject area. The subject area should be considered as comprising a portion of the foraging range of this species. No other species listed as endangered or threatened, or candidates for such listing by Washington or federal governments, or species listed as monitor species by Washington State, were observed on the proposed SNF site.

Table 4.9-2. Candidate species.

Common Name	Scientific Name	Federal	State
Mollusks			
Shortfaced lanx	Fisherola (=Lanx) nuttalli		X
Columbia pebble snail	Fluminicola (=Lithoglyphus) columbiana	X	X
Birds			
Common loon	Gavia immer		X
Swainson's hawk	Buteo swainsoni		X
Ferruginous hawk	Buteo regalis	X	
Western sage grouse	Centocrcus urophasianus phaios	X	X
Sage sparrow	Amphispiza belli		X
Burrowing owl	Athene cunicularia		X
Loggerhead shrike	Lanius ludovicianus	X	X

Northern goshawk	*Accipter gentilis*	X	
Harlequin duck	*Histrionicus histrionicus*	X	
Lewis' woodpecker	*Melanerpes lewis*		X
Long-billed curlew	*Numenius americanus*	X	
Sage thrasher	*Oreoscoptes montanus*		X
Flammulated owl	*Otus fammeolus*		X
Western bluebird	*Sialia mexicana*		X
Tricolored blackbird	*Agelaius tricolor*	X	
Golden eagle	*Aquila chrysaetos*		X
Black tern	*Chlidonius niger*	X	
Mammals			
Merriam's shrew	*Sorex merriami*		X
Pacific western big-eared bat	*Plecotus townsendii townsendii*	X	
Pygmy rabbit	*Brachylagus idahoensis*	X	
Insects			
Columbia River tiger beetle	*Cinindela columbica*		X
Plants			
Columbia milk-vetch	*Astragalus columbianus*	X	
Columbia yellowcress	*Rorippa columbiae*	X	
Hoover's desert parsley	*Lomatium tuberosum*	X	
Northern wormwood	*Artemisia campetis borealis* var. *wormskioldii*	X	

Table 4.9-3. Washington plant species of concern occurring on the Hanford Site.

Common Name	Scientific Name	Status[a]
Dense sedge	*Carex densa*	S
Gray cryptantha	*Cryptantha leucophaea*	S
Bristly cyptantha	*Cryptantha interrupta*	S
Shining flatsedge	*Cyperus rivularis*	S
Piper's daisy	*Erigeron piperianus*	S
Southern mudwort	*Limosella acaulis*	S
False-pimpernel	*Lindernia anagallidea*	S
Dwarf desert primrose	*Oenothera pygmaea*	S
Desert dodder	*Cuscuta denticulata*	M1
Thompson's sandwort	*Arenaria franklinii* v. *thompsonii*	M2
Robinson's onion	*Allium robinsonii*	M3
Columbia River mugwort	*Artemisia lindleyana*	M3
Stalked-pod milkvetch	*Astragalus sclerocarpus*	M3
Medick milkvetch	*Astragalus speirocarpus*	M3
Crouching milkvetch	*Astragalus succumbens*	M3
Rosy balsamroot	*Balsamorhiza rosea*	M3
Palouse thistle	*Cirsium brevifolium*	M3
Smooth cliffbrake	*Pellaea glabella*	M3
Fuzzy beardtongue penstemon	*Penstemon eriantherus*	M3
Squill onion	*Allium scillioides*	M3

The following species may inhabit the Hanford Site, but have not been recently collected, and the known collections are questionable in terms of locations or identification.

Palouse milkvetch	*Astragalus arrectus*	S
Few-flowered blue-eyed Mary	*Collinsia sparsiflora*	S
Coyote tobacco	*Nicotiana attenuata*	S

a. Abbreviations: S, sensitive; taxa vulnerable or declining, and could become endangered or threatened without active management or removal of threats. M1, Monitor group 1; taxa for which there are insufficient data to support listing as threatened, endangered, or sensitive. M2, Monitor group 2; taxa with unresolved taxonomic questions. M3, Monitor group 3; taxa that are more abundant or less threatened than previously assumed.

4.9.5 Radionuclide Levels in Biological Resources

Samples of vegetation and wildlife are routinely collected as part of the site environmental monitoring program and analyzed for various radionuclides. The following summarizes the levels reported in Woodruff and Hanf (1993).

A single sample of vegetation collected on the Hanford Site contained 0.015 picocuries strontium-90 per gram dry weight and 0.0059 picocuries cesium-137 per gram dry weight. These values are lower by nearly an order of magnitude from those reported for the previous five years. Mean values of cesium-137 in upland gamebird muscle (n = 4) in 1992 were 0.02 picocuries per gram wet weight and were about an order of magnitude higher than similar samples collected off of the Hanford Site the previous five years (n = 42). Mean values of cesium-137 in rabbit muscle (n = 12) were 0.09 picocuries per gram wet weight and exceed those collected on the Hanford Site the previous five years (n = 27) by about threefold, and were an order of magnitude higher than samples collected off of the Hanford Site. Values for strontium-90 in rabbit bone (n = 12) had a mean value of 4.08 picocuries per gram wet weight; mean values collected on the Hanford Site for the previous five years (n = 37) were 43 picocuries per gram wet weight, an order of magnitude higher. Mean strontium-90 concentrations in the bones of rabbits (n = 20) collected off of the Hanford Site were 0.37 picocuries per gram wet weight. One sample of muscle collected from a deer in the 200-Areas contained 0.006 picocuries cesium-137 per gram wet weight, nearly two orders of magnitude less than a similar sample collected off of the Hanford Site. Fish populations are safe for human consumption. Radionuclide levels of fish from the Hanford Reach are not significantly higher than those of fish found upstream. Because the confluence of the Snake and Columbia Rivers is downstream from the Hanford Site, the Snake River salmon runs do not migrate through the Hanford reach.

4.10 Noise

Noise is technically defined as sound waves perceptible to the human ear. Sound waves are characterized by frequency, measured in Hertz (Hz), and sound pressure expressed as decibels (dB). Noise levels are often reported as the equivalent sound level (Leq), which normally refers to the equivalent continuous sound level for an intermittent sound, such as traffic noise. The Leq is expressed in A-weighted decibels (dBA) over a specified period of time and is a frequency-weighted measure of sound level related to human hearing characteristics and the concept of equal loudness.

4.10.1 Hanford Site Sound Levels

Most industrial facilities on the Hanford Site are located far enough away from the site boundary that noise levels at the boundary are not measurable or are barely distinguishable from background noise levels. Modeling of environmental noises has been performed for commercial reactors and State Highway 240 through the Hanford Site. These data are not concerned with background levels of noise and are not reviewed here. Two studies of environmental noise were done at Hanford, as described in subsections 4.10.2 and 4.10.3. One study reported environmental noise measurements taken in 1981 during site characterization of the Skagit/Hanford Nuclear Power Plant Site (NRC 1982). The second was a series of site characterization studies performed in 1987 that included measurement of background environmental noise levels at five places on the Hanford Site. Additionally, such activities as well drilling and sampling have the potential for producing noise in the field apart from major permanent facilities. Noise can be disruptive to wildlife and studies have been done to compile noise data in remote areas.

4.10.2 Skagit/Hanford Data

Preconstruction measurements of environmental noise were taken in June 1981 on the Hanford Site (NRC 1982). Monitoring was conducted at 15 sites, showing point noise level reading ranging from 30 to 60.5 dBA. The corresponding values for more isolated areas ranged from 30 to 38.8 dBA. Measurements taken in the vicinity of the sites where the Washington Public Power Supply System was constructing nuclear power plants ranged from 50.6 to 64 dBA, reflecting operation of construction equipment. Measurements taken along the Columbia River near the intake structures for WNP-2 were 47.7 and 52.1 dBA, compared to more remote river noise levels of 45.9 dBA (measured about three miles upstream of the intake structures). Community noise levels from point measurements in North Richland (3000 Area at Horn Rapids Road and Stevens Road [Route 240]) were 60.5 dBA, largely attributed to traffic. North Richland is about 20 miles from the proposed site for SNF facilities.

4.10.3 Basalt Waste Isolation Project Data

Background noise levels were determined at five sites located within the Hanford Site. Noise levels are expressed as equivalent sound levels for 24 hours (Leq-24). The average noise level for these five sites was 38.8 dBA on the dates tested. Wind was identified as the primary contributor to background noise levels with winds exceeding 12 mph significantly affecting noise levels. This study concluded that background noise levels in undeveloped areas at Hanford can best be described as a mean Leq-24 of 24 to 36 dBA (Cushing 1992). Periods of high wind, which normally occur in the spring, would elevate background noise levels.

4.10.4 Noise Levels of Hanford Field Activities

In the interest of protecting Hanford workers and complying with Occupational Safety and Health Administration (OSHA) standards for noise in the workplace, the Hanford Environmental Health Foundation has monitored noise levels resulting from several routine operations performed in the field at Hanford. These included well drilling, pile driving, compressor operations, and water wagon operation. Occupational sources of noise propagated in the field from outdoor activities ranged from 93.4 to 96 dBA.

4.10.5 Noise Related to the Spent Nuclear Fuel Facility

Ambient noise levels at the proposed project SNF site just west of the 200-East Area on the Hanford Site are very low and would be expected to be less than 40 dBAs. The land is currently vacant, and no vehicular traffic transverses the site. A lightly used road borders the eastern side of the proposed SNF site and occasional traffic generates moderate amounts of vehicular noise, but only for those personnel near the road. Existing traffic noise on the Hanford Site is centered primarily on the main arteries leading into the site. These are Route 4 South, which connects with the Richland Bypass (Route 240) and eventually with Interstate 182. Another main road is Route 10, which also connects with Route 240 and leads into the 200 Areas in the site center. It is estimated that 3,300 privately owned vehicles travel to and from the site each day using these roads. The vast majority of the privately owned vehicle movement occurs during the rush hours of 6 to 8 a.m. and 3:30 to 6 p.m. In addition, it is estimated that 3,600 oncoming truck shipments, 445 oncoming rail shipments, and 837 intrasite truck shipments occur each day on the Hanford Site. The movement of all this vehicular traffic generates noise along these affected road corridors. However, little, if any, population exists along these roadways because of the geographic remoteness of work areas on the Hanford Site. Information on noise contours generated by peak rush hour traffic in terms of community Leqs and dBAs is not available at this time.

4.10.6 Background Information

Studies at Hanford of noise propagation have been concerned primarily with occupational noise at work sites. Environmental noise levels have not been extensively evaluated due to the remoteness of most Hanford activities and their isolation from receptors that are covered by federal or state statutes. The Noise Control Act of 1972 and its subsequent amendments (Quiet Communities Act of 1978, 42 USC 4901-4918, 40 CFR 201-211) empower the state to direct. The State of Washington has adopted RCW 70.107, which authorizes the Washington Department of Ecology to implement rules consistent with federal noise control legislation. The Hanford Site is currently in compliance with state and federal noise regulations.

4.11 Traffic and Transportation

4.11.1 Regional Infrastructure

This section discusses the existing transportation environment at and around the Hanford Site. Personnel and most material shipments are transported by road. Bulk materials or large items are shipped by barge. Rail transportation is used only to move irradiated fuel, certain high-level radioactive solid wastes, equipment, and materials (primarily coal). High-level and low-level wastes from spent fuel stabilization are transported to waste management facilities by pipeline.

The regional transportation network in the Hanford vicinity includes the areas in Benton and Franklin Counties from which 93 percent of the commuter traffic associated with the site originates. Interstate highways that serve the area are I-82, I-182, and I-90 (Figure 4-19). Interstate-82 is 8 kilometers (5 miles) south-southwest of the site. Interstate-182, a 24-kilometer (15-mile) long urban connector route 8 kilometers (5 miles) south-southeast of the site, provides an east-west corridor linking I-82 to the Tri-Cities area. Interstate-90 (not shown in Figure 4-19), located north of the site, is the major link to Seattle and Spokane and extends to the east coast; SR 224 (not shown in Figure 4-19), also south of the site, serves as a 16-kilometers

Figure 4-19. Transportation routes in the Hanford vicinity.

(10-mile) link between I-82 and SR 240. State Route 243 exits the northwestern boundary of the site and serves as a primary link between Hanford and I-90. State Route 24 enters the site from the west, continues eastward across the northernmost portion of the site, and intersects SR 17 approximately 24 kilometers (15 miles) east of the site boundary. State Route 17 is a north-south route that links I-90 to the Tri-Cities and joins U.S. Route 395, which continues south through the Tri-Cities. State Route 14 (not shown in Figure 4-19) connects with I-90 at Vantage, Washington, and provides ready access to I-84 (not shown in Figure 4-19) at several locations along the Oregon and Washington border.

General weight, width, and speed limits have been established for highways in the Hanford vicinity. However, no unusual laws or restrictions that have been identified would significantly influence general regional transportation.

Airline passenger and air freight service is provided at the Tri-Cities Airport owned and operated by the Port of Pasco, at Pasco, Washington. The air terminal is located approximately 16 kilometers (10 miles) from the Hanford Site. Delta Airlines provides domestic Boeing-737 and 727 service to Salt Lake City where multiple major airline service is available for domestic and international travel. Two feeder airlines service

the Tri-Cities:
United Express, a subsidiary of United Airlines, and Horizon Airlines, a subsidiary of Alaska Airlines, provide service to Seattle, Portland, and several other regional cities. Federal Express serves the Tri-Cities by charter airplane from Spokane to Pasco and Airborne Express serves the Tri-Cities with charter airplane from Seattle to the Richland airport, Richland, Washington.

4.11.2 Hanford Site Infrastructure

Hanford's onsite road network consists of rural arterial routes (see Figure 4-20). Only 104 of the 461 kilometers (65 of the 288 miles) of paved roads at Hanford are accessible to the public. Most onsite employee travel occurs along Route 4, with controlled access at the Yakima and Wye barricades. State Route 240 is the main public route through the site. Public highways SR 24 and SR 243 also traverse the site.

The highway network is in excellent condition. A recently completed major highway improvement project involved repavement and widening of the four-lane access route to the Wye Barricade. The highway network has been used extensively for transporting large equipment items, construction materials, and radioactive materials. Resurfacing, sealing, and restoration programs are currently planned for segments of SR 17, SR 224, SR 240, and U.S. Route 395.

Figure 4-20. Transportation routes on the Hanford Site.

In 1988 about 32 percent of the work force at Hanford worked in offices in Richland. The remaining work force was on the site. Approximately 80 percent of the work force resides in the Tri-Cities: Richland (45 percent), Kennewick (28 percent), and Pasco (7 percent). Approximately 1600 of the employees on the site use bus transportation.

In 1988 nearly 12 million miles were logged by DOE vehicles at Hanford. In addition, an estimated 3,300 privately owned vehicles were driven onsite each weekday and 560 were driven onsite each weekend day. Assuming a round-trip distance of 30 miles onsite for each of these vehicles, a total of about 40 million miles were driven annually by workers onsite.

The primary highways used by commuters are SR 24, SR 240, and I-182; 10, 90, and 10 percent of the work force use these routes, respectively (totals to more than 100 percent because some commuters use two of the routes). With these commuting patterns, workers annually travel about 27 million miles offsite. Trucks used for material shipment to Hanford compose about 5 percent of the vehicular traffic on and around the site. At present there are periods of moderate traffic congestion, some of which is expected to be alleviated by a new road to the 200 Areas.

During 1988, 169 accidents were reported onsite, with 20 involving DOE vehicles. The other accidents involved privately owned vehicles and included seven injury accidents and one fatal accident on SR 240. Among offsite highway segments of concern, most accidents occurred along I-82. According to available data, the 15 accidents involving trucks in 1987 in the Benton/ Franklin county study area resulted in 13 injuries and 3 fatalities.

Onsite rail transport is provided by a short-line railroad owned and operated by DOE. This line connects just south of the Yakima River with the Union Pacific line, which in turn interchanges with the Washington Central and Burlington Northern railroads at Kennewick. AMTRAK passenger rail service is provided in the Tri-Cities at the Burlington Northern depot at Pasco. Approximately 145,000 rail miles were logged at Hanford in 1988, primarily transporting coal to steam plants. Two noninjury rail accidents occurred at Hanford in 1988.

The Hanford Site infrequently uses the Port of Benton dock facilities on the Columbia River for off-loading large shipments. Overland wheeled trailers are then used to transport those shipments to the site. No barge accidents were reported in 1988.

4.12 Occupational and Public Health and Safety

This section summarizes the Hanford Site programs designed to protect the health and safety of workers and the public. It also describes existing radiological and nonradiological conditions and provides a historical perspective on worker and public exposures and potential health effects.

The section is based on existing documentation and generic descriptions. Reference is made to policies, orders, guidance documents, annual occupational exposure and environmental reports, and to other site descriptive documents. The parameters of greatest interest are the history of radiological releases and worker radiation doses, particularly those associated with the storage of SNF.

The DOE, the DOE-RL, and all Hanford Site contractors have established policies to help ensure a safe and healthful workplace for all employees and visitors and to protect the environment and public health and safety. The DOE-RL manager has the overall responsibility for safety and health at the Hanford Site. Each contractor develops and enforces occupational and public health and safety programs that meet or exceed the requirements of DOE orders, other federal agencies, and Washington State.

4.12.1 Occupational Health and Safety

Programs are in place at the Hanford Site to protect workers from radiological and nonradiological hazards. Radiological protection (health physics) programs are based on requirements in regulations and DOE orders, and on guidance in radiological control manuals. Occupational nonradiological health and safety programs are composed of industrial hygiene programs and occupational safety programs.

4.12.1.1 Radiological Health and Safety/Health Physics Program. In order to help ensure that

workers at DOE facilities are adequately protected from ionizing radiation, the DOE promulgates radiation protection standards for occupational workers. These standards include radiation dose limits to control worker dose from both external radiation and internally deposited radionuclides. The current radiation dose limits were promulgated in 10 CFR Part 835, "Occupational Radiation Protection," which was enacted in 1993. This regulation includes limits on total effective dose equivalent to workers, dose to individual organs, and dose to members of the public (including minors and unborn children of workers) that may be incidentally exposed while at DOE facilities.

Hanford contractors base their radiological protection programs, procedures, and manuals primarily on 10 CFR Part 835. This regulation establishes the criteria for radiation protection for occupational workers. It lists allowable doses, establishes a policy on keeping doses as low as reasonably achievable, and specifies training requirements for radiation protection personnel and other workers. The DOE Radiological Control Manual, DOE/EH-0256T, issued by DOE Headquarters, establishes practices for conducting radiological control activities at all DOE sites. The DOE requires monitoring and reporting of radiation exposure records for individual workers and certain visitors. Monitoring is required by 10 CFR Part 835 when the potential exists for an individual to receive an annual effective dose equivalent above 100 millirem (1 millisievert), or an annual dose equivalent to an individual organ greater than 10 percent of DOE occupational exposure limits. Personnel to be monitored are assigned a thermoluminescent dosimeter that is worn at all times during radiation work on the Hanford Site. This instrument measures the amount and type of external radiation dose the worker receives. Dosimeters for all DOE and contractor personnel are processed by Pacific Northwest Laboratory. The centralized operational dosimetry program reads, records, and summarizes results of dosimetry data as required. Records of occupational exposure are maintained, and reports of radiation dose are provided annually to each worker. Summary reports are also provided to DOE and published periodically (Smith et al. 1992)

4.12.1.2 Radiation Doses to Workers. The reported cumulative doses to all Hanford Site workers and

visitors for all activities are given as a baseline for site operations.

In 1993, about 14,500 workers were monitored at the Hanford Site. Of those monitored, 11,000 were classified as radiation workers, with an average annual dose equivalent of 0.02 rem per individual (Lyon). This dose is well below the 10 CFR Part 835 dose limit of 5 rem per year and the DOE Administrative Control Level of 2 rem per year for occupational exposure.

For 1993, the estimated collective dose-equivalent was 200 person-rem for all Hanford Site radiation workers. Based on standard dose-to-health effects conversion factors (ICRP 1991), no health effects would be expected to result among workers so exposed.

The worker radiation dose of most interest in this document is the cumulative collective dose to SNF workers, which is described in the following subsection. The SNF management alternatives considered in this document are similar to those current work activities associated with maintenance and storage of SNF at the Hanford Site.

4.12.1.3 Radiation Dose to K-Basin Workers. On the Hanford Site the bulk of the SNF is stored in the

105-KE and 105-KW Basins, which are collectively referred to as the K-Basins. The K-Basins are located within the 100-K Area of the Hanford Site. The basins are filled with recirculating water to cool the fuel and to provide radiological shielding for personnel working in the facility. Westinghouse Hanford Company (WHC) operates the K Basins for DOE. Therefore the best measure of radiation dose from SNF is the dose to WHC employees assigned to work at the K Basins. The collective radiation dose to WHC K Basin workers over the 2-year period 1991 and 1992 averaged 22 person-rem per year, or approximately 0.4 rem per year for each worker. An average of 58 workers were assigned to the K-Basin during 1991 and 1992, or approximately 29 workers per basin (Holloman and Motzco 1992, 1993).

The nominal collective radiation dose per year of operation of each SNF basin in the 100-K Area is estimated to be 11 person-rem. During the plutonium production mission, each reactor at the Hanford Site had a similar nuclear fuel storage basin associated with its operation. This resulted in an estimated total radiation dose of 2000 person-rem, assuming 179 total operating reactor years plus six years of K-Basin operation following shutdown of the production reactors (Bergsman 1994). Therefore, operation of nuclear fuel storage basins has accounted for approximately 2.4 percent of the total radiological dose received by all Hanford Site workers from 1945 through 1985, 86,100 rem (Gilbert et al. 1993). Based on standard dose-to-health effects conversion factors (ICRP 1991), the dose to SNF workers since Hanford start up would statistically relate to one fatal cancer among these workers.

4.12.1.4 Worker Safety and Accidents. No incidents of overexposure to radiation have been reported to

DOE during 1990 and 1991 in association with SNF storage activities at the Hanford Site. Overexposures are defined as any exposure over regulatory limits established by the DOE (WHC 1990; Lansing et al. 1992).

In the four-year period from 1991 through 1994, industrial-type accidents resulted in 98 lost working days at the K Basins out of a total of approximately 70,000 days worked.

4.12.1.5 Industrial Hygiene Program. Occupational nonradiological health and safety programs at

Hanford are composed of industrial hygiene and occupational safety programs. Industrial hygiene programs address such subjects as toxic chemicals and physical agents, carcinogens, noise, biological hazards, lasers, asbestos, and ergonomic factors. Occupational safety programs address such subjects as machine safety, hoisting and rigging, electrical safety, building codes, welding safety, and compressed gas cylinders.

The governing document is DOE 5480.10, "Contractor Industrial Hygiene Program," dated 6-26-85. The DOE-RL implementing procedure for DOE 5480.10 is RLIP 5480.10 "Industrial Hygiene Program," dated 7-30-90. The procedure establishes additional requirements and direction for implementation of an industrial hygiene program for DOE-RL and its contractors. In addition to the program requirements of DOE 5480.10, the RL Industrial Health Program addresses the following subject areas:

(1) Use of respiratory equipment
(2) Asbestos material
(3) Regulated carcinogen or suspect carcinogenic materials
(4) Sanitation
(5) Control of hazardous materials
(6) Filter testing
(7) Hearing conservation
(8) Indoor air quality
(9) Human factors
(10) Hazardous waste site safety/health management.

The responsibilities and authorities of the Occupational Medical Services Contractor (contracted by DOE to Hanford Environmental Health Foundation) of the Industrial Health Program are also described in DOE 5480.10. These are 1) to provide technical industrial health support services, that is, air and water monitoring; 2) to evaluate, recommend, and train workers in the use of respiratory devices, as requested by DOE-RL and its contractors; 3) to provide an industrial health analytical laboratory; 4) to conduct work environment surveys; 5) to support noise abatement and hearing conservation; and 6) to maintain permanent records of personal exposure monitoring data. Hanford Environmental Health Foundation maintains centralized records and provides DOE-RL and its contractors with the results of monitoring efforts.

The RL contractors are required to do the following:

- Conduct an effective program to educate employees on the potential health hazards in their work environment, the control measures, and the protection necessary to reduce those risks to acceptable levels.

- Inform employees of health hazards and the results from monitoring of harmful toxic or physical agents in the work environment, and document this action.

Records are maintained in accordance with DOE 1324.2, DOE 5483.1A, and DOE 5484.1. Contractors of DOE-RL are required to maintain records of employee toxic and physical agent exposure and potential personal exposure data. Contractors of DOE-RL are also required to maintain Hanford Site material safety data sheets.

The DOE requires that as low as reasonably achievable (ALARA) principles for radiological and nonradiological hazardous materials be applied in the preparation of all health and safety plans, and that all such ALARA criteria are followed during the course of the work.

Training requirements consistent with 29 CFR 1910.120 for entry into sites potentially containing toxic or hazardous material are specified by DOE (29 CFR OSHA 1991).

The DOE-RL requires that all work (including preliminary investigation activities) be conducted in such a manner that it conforms to applicable federal and state safety and health standards and that all operating equipment meets all safety and operability standards and requirements.

4.12.2 Public Health and Safety

The DOE has the responsibility under the Atomic Energy Act to establish the necessary standards to protect members of the public from radiation exposures resulting from DOE activities. In addition, Presidential Order 12088, "Federal Compliance with Pollution Control Standards," requires all federal facilities to comply with the legislative acts and regulations relating to the prevention, control, and abatement of environmental pollution. The Hanford Site is also in compliance with EPA's National Emission Standards for Hazardous Air Pollutants for Radionuclides, 40 CFR 61, Subpart H. The EPA offsite air emissions limiting standard is 10 millirem/year effective dose equivalent to the public. The National Primary Drinking Water Regulations of the Safe Drinking Water Act apply to the drinking water supplies at the Hanford Site. Several radionuclides are included in these water standards (40 CFR 141, 142; 56 FR 33050-33127, 1991) For 1993, the Hanford Site Environmental Report (Dirkes et al. 1994) relates that the facility is in compliance with these requirements.

4.12.2.1 Environmental Programs. DOE 5400.1, "General Environmental Protection Program,"

establishes the requirement for environmental protection programs. The Hanford Site Environmental Report is prepared annually pursuant to DOE 5400.1 to summarize environmental data that characterize Hanford Site environmental management performance and regulatory compliance status. The most recent report summarizes the status in 1993 of compliance with environmental regulations, describes programs at the Hanford Site, discusses estimates of radiation dose to the public from Hanford activities, and presents information on effluent monitoring and environmental surveillance, including groundwater monitoring (Dirkes et al. 1994). In 1993, environmental programs were conducted at the Hanford Site to restore environmental quality, manage waste, develop appropriate technology for cleanup activities, and study the environment.

4.12.2.2 Environmental Monitoring/Surveillance Information. Environmental monitoring at the

Hanford Site consists of effluent monitoring and environmental surveillance, including groundwater monitoring. Effluent monitoring is performed by the operators at the facility or at the point of release to the environment. Environmental surveillance consists of sampling and analyzing environmental media on and off the Hanford Site to detect and quantify potential contaminants and to assess their environmental and human health significance. The annual Hanford Site Environmental Reports (Dirkes et al. 1994) present a summary of this information for the Hanford Site. The Hanford Site operations contractor, Westinghouse Hanford Company, also reports summary data annually on radioactive and nonradioactive materials released into the environment from facilities they manage (WHC 1993a). Several federal and state laws and regulations require the reporting of radioactive and nonradioactive releases. The Hanford Site reports pursuant to the federal Clean Air Act (Diediker et al. 1994) and Clean Water Act.

4.12.2.3 Natural Cancer Incidence. The probability of an American contracting cancer in their lifetime is 340 in 1000 (American Cancer Society 1993), and 20 percent of Americans will die from cancer, an estimated 526,000 cancer deaths in 1993. Table 4.12-1 shows the estimated 1993 cancer incidence for different types of cancer for the United States and for Washington State. For the United States the probability of contracting cancer in 1993 is 4.9 in 1000, and 2.2 in 1000 of dying from that cancer. For Washington State the probability of contracting cancer in 1993 is 3.2 in 1000, and 1.4 in 1000 of dying from that cancer.

The expected survival period for cancer victims has increased as detection and treatment technologies have improved. Currently, 40 percent of the victims of all forms of cancer survive for at least 5 years.

4.12.2.4 Potential Radiation Doses. Potential radiation doses and exposures to members of the public from releases of radionuclides to air and water at the Hanford Site are calculated and reported annually by the Surface Environmental Surveillance Project at the Pacific Northwest Laboratory.

Table 4.12-1. Estimated 1993 cancer incidence and cancer deaths in the United States and the state of Washington for different forms of cancer (American Cancer Society 1993).

	United States[a] 1993		Washington State[b] 1993	
Type of Cancer	Estimated new cases	Estimated deaths	Estimated new cases	Estimated deaths
All types & sites	1,170,000	526,000	14,825	6,350
Female breast	182,000	46,000	3,300	850
Colon & rectum	152,000	57,000	2,400	950
Lung	170,000	149,000	3,100	2,700
Oral	29,800	7,700	500	125
Uterus	44,500	10,100	600	125
Prostate	165,000	35,000	3,300	700
Skin melanoma	32,000	6,800	600	125
Pancreas	27,700	25,000	475	425
Leukemia	29,300	18,600	550	350

a. Total population 250 million.
b. Total population 5 million.

4.12.2.4.1 Maximally Exposed Individual (MEI) Dose.

The MEI is defined in the Hanford Site Environmental Report as "an hypothetical person who lives at a location and has a lifestyle such that it is unlikely that other members of the public would receive higher radiation doses" (Dirkes et al. 1994). The potential radiation doses to MEI have been published in annual Hanford Site Environmental Reports since 1957. For 1993, the total potential dose (via air and water pathways) to the MEI from Hanford operations was calculated to be 0.03 mrem (Dirkes et al. 1994). Estimates of the potential cumulative Effective Dose Equivalent (EDE) to the MEI from both air and water sources for the 28-year period 1994 through 1972 were reconstructed by the Hanford Environmental Dose Reconstruction (HEDR) Project (TSP 1994).

The highest cumulative dose to an adult resident for the years 1944 through 1972 from pathways associated with releases to the air was 1 rem; almost all of this dose was received during 1945. The highest cumulative dose to an adult resident for the years 1944 through 1971 from pathways associated with releases to the water was 1.5 rem; about one-half of this was received during the period from 1954 through 1964. Thus the total cumulative dose from both air and water releases was about 2.5 rem. For comparison, the dose received by an average resident during this 28-year period from natural background radiation was approximately 9 rem. Radiation doses received by the public from Hanford releases after 1972 were vanishingly small.

The maximum cumulative dose to the thyroid of a small child for the years 1944 through 1951 was estimated to be 240 rad; the majority of this dose was received during 1945.

4.12.2.4.2 Population Dose - Estimates of the potential cumulative dose to the population

within 50 miles (80 km) of the Hanford Site for 1944 through 1972 were estimated from the releases to air and water developed by the Hanford Environmental Dose Reconstruction (HEDR) project. Pathways of exposure associated with releases to the air dominated the population doses until after 1954 when their contribution decreased rapidly. The cumulative population dose during 1944 through 1972 was 100,000 person-rem; essentially all of this dose was received through air pathways in 1945. The cumulative population dose during 1944 through 1972 associated with water pathways was estimated to be about 6,000 person-rem; most of this dose was received during the decade between 1954 and 1964.

The total potential radiation dose to the population within 50 miles (80 km) for 1993 was 0.4 person-rem (Dirkes et al. 1994). By comparison, the total dose received in 1993 by this same population was about 110,000 person-rem.

About 50 cancer deaths would be implied by the total public radiation dose from Hanford activities since 1944 using standard dose-to-health-effects conversion factors (ICRP 91). Essentially all of these would have been a result of radiation exposures received during 1945. For perspective, the population within 50 miles (80 km) of the Site would have experienced about 75,000 cancer deaths in 1993 from all causes.

4.13 Site Services

4.13.1 Water Consumption

The principal source of water in the Tri-Cities and the Hanford Site is the Columbia River, from which the water systems of Richland, Pasco, and Kennewick draw a large portion of the average 4.3 x 107 cubic meters (11.38 billion gallons) used in 1991. Each city operates its own supply and treatment system. The Richland water supply system derives about 67 percent of its water from the Columbia River, approximately 15 to 20 percent from a well field in North Richland, and the remaining from groundwater wells. The city of Richland's total usage in 1991 was 2.1 x 107 cubic meters (5.65 billion gallons). This current usage represents approximately 58 percent of the maximum supply capacity. The city of Pasco system also draws from the Columbia River for its water needs; the 1991 estimate of consumption is 1.1 x 107 cubic meters (2.81 billion gallons). The Kennewick system uses two wells and the Columbia River for its supply. These wells serve as the sole source of water between November and March and can provide approximately 62 percent of the total maximum supply of 2.8 x 107 cubic meters (7.3 billion gallons). Total usage of those wells in 1991 was 1.1 x 107 cubic meters (2.92 billion gallons).

4.13.2 Electrical Consumption

Electricity is provided to the Tri-Cities by the Benton County Public Utility District, Benton Rural Electrical Association, Franklin County Public Utility District, and City of Richland Energy

Services Department.
All the power that these utilities provide in the local area is purchased from the Bonneville Power Administration, a federal power marketing agency. The average rate for residential customers served by the three local utilities is approximately $0.0396 per kilowatt hour. Electrical power for the Hanford Site is purchased wholesale from the Bonneville Power Administration. Energy requirements for the site during FY 1988 exceeded 550 average megawatts.

Natural gas, provided by the Cascade Natural Gas Corporation, serves a small portion of residents, with 4800 residential customers in June 1992.

In the Pacific Northwest, hydropower, and to a lesser extent, coal and nuclear power, constitute the region's electrical generation system. Total generating capacity is about 40,270 megawatts. Approximately 74 percent of the region's installed generating capacity is hydroelectric, which supplies approximately 65 percent of the electricity used by the region. Coal-fired generating capacity is 6,702 megawatts in the region, 16 percent of the region's electrical generating capacity. Two commercial nuclear power plants are in service in the Pacific Northwest, with a 2247-megawatt capacity of 6 percent of the region's generating capacity. Oil and natural gas account for about 3 percent of capacity.

The region's electrical power system, more than any other system in the nation, is dominated by hydropower. On average, the region's hydropower system can produce 16,400 megawatts. Variable precipitation and limited storage capabilities alter the system's output from 12,300 average megawatts under critical water conditions to 20,000 average megawatts in record high water years. The Pacific Northwest system's reliance on hydroelectric power means that it is more constrained by the seasonal variations in peak demand than in meeting momentary peak demand.

Throughout the 1980s, the Northwest had more electric power than it required and was operating with a surplus. This surplus has been exhausted, however, and there is only approximately enough power supplied by the existing system to meet the current electricity needs. Hydropower improvement projects currently under construction in the Northwest include about 150 megawatts of new capacity. The cost and availability of several other resources are currently being studied (Northwest Power Planning Council 1986). Approximate rates for current consumption of electricity, coal, propane, natural gas, and other utilities at the Hanford Site are shown in Table 4.13-1.

4.13.3 Waste Water Disposal

The major incorporated areas of Benton and Franklin counties are served by municipal wastewater treatment systems, whereas the unincorporated areas are served by onsite septic systems. Richland's wastewater treatment system is designed to treat a total capacity of 27 million cubic meters per year (a daily average flow of 8.9 million gallons per day with a peak flow of 44 million gallons per day). In 1991 the system processed an average of 4.83 million gallons per day. The Kennewick system similarly has significant excess capacity, with a treatment capability of 12 million cubic meters per year (8.7 million gallons per day); 1991 usage was 4.8 million gallons per day. Pasco's waste-treatment system processes an average of 2.22 million gallons per day, while the system could treat 4.25 million gallons per day or 16.2 liters per day.

4.14 Materials and Waste Management

This section discusses the management of materials and waste and presents both a historic overview and the current status of the various waste types being generated and stored at the Hanford Site. Regulatory requirements governing the management of these materials and wastes are discussed in Section 2.2.

Table 4.13-1. Approximate consumption of utilities and energy on the Hanford Site (1992).

Energy	Consumption	
Electricity	340,000 megawatt-hours	
Coal	45,000 metric tons	(50,000 tons)
Fuel Oil	83,000 cubic meters	(22,000,000 gallons)
Natural Gas	680,000 cubic meters	(24,000,00 cubic feet)
LPG-propane	110 cubic meters	(29,000 gallons)
Gasoline	3,600 cubic meters	(950,000 gallons)
Diesel	1,700 cubic meters	(450,000 gallons)
Other Utilities		
Water	15,000,000 cubic meters	(4,000+ million gallons)
Power Demand	57 megawatts	

In order for Hanford programs to meet operational and mission requirements, many hazardous materials are or have been used onsite. Hazardous materials are not waste, but when no longer useful, may become waste. Because of the potential for impacts to human health and the environment, hazardous materials have been included in Subsection 4.14.7.

Wastes at the Hanford Site are generated by both facility operations and environmental restoration activities. Facility operations include nuclear and non-nuclear research, materials testing, laboratory analysis, high-level waste stabilization, and nuclear fuel storage, manufacturing, repair and maintenance, and general office work. They also include operation of all waste management facilities for treatment, storage, or disposal of Hanford wastes, as well as any waste shipped to Hanford for storage or disposal. Environmental restoration operations include remediation (identifying and arranging for the cleanup of inactive waste sites) and decontamination and decommissioning of surplus facilities.

Wastes and materials handled at the Hanford Site are described in subsections 4.14.1 through 4.14.7. These wastes and materials have been classified as high-level waste (discussed in detail in subsection 4.14.1), transuranic waste (discussed in detail in subsection 4.14.2), mixed low-level waste (discussed in detail in subsection 4.14.3), low-level waste (discussed in detail in subsection 4.14.4), hazardous waste (discussed in detail in subsection 4.14.5), industrial solid waste (discussed in detail in subsection 4.14.6), and hazardous materials (discussed in detail in subsection 4.14.7). Table 4.14-1 shows expected waste disposal rates as of the year 2000, including the expected disposition.

The total amount of waste generated and disposed of at the Hanford Site has been, and is being, reduced through the efforts of the pollution prevention and waste minimization programs at the site. The Hanford Waste Minimization (and Pollution Prevention) Program is an ambitious program aimed at source reduction, product substitution, recycling, surplus chemical exchange, and waste treatment. The program is tailored to meet Executive Order 12780, DOE orders, RCRA, and EPA guidelines. All wastes on the Hanford Site, including radioactive, mixed, hazardous and non-hazardous regulated wastes are included in the Hanford Waste Minimization Program.

Table 4.14-1. Baseline waste quantities as of the year 2000 at Hanford[a].

Waste identification	Annual disposal volume from stabilization operations wastes (m3/yr)	Annual disposal volume from stabilization of stored wastes (m3/yr)	Total annual disposal volume from all waste stabilization (m3/yr)	Disposition
High-level waste	0	240	240[c]	Interim onsite solid[b] storage[d]
Transuranic waste	0	170	170[c]	Interim onsite solid[e] storage[f]
Low-level waste	13,000	7,000	20,000	Onsite solid[g]

disposal			
Mixed waste	300	0	300
Interim onsite			
solid[g]			
storage			
Hazardous waste	100	0	100
Offsite			
liquid and solid			
disposal			
Other waste			
nonhazardous			
liquid	2,000,000	10,000,000	12,000,000
Liquid effluent			
solid	38,000	0	38,000
Onsite disposal			
sewage			
liquid[h]	210,000	0	210,000
Liquid effluent			
solid[i]	4	0	4
Onsite disposal			

a. Baseline values are projected from 1988 data.
b. Liquid high-level waste (HLW) is held in interim storage and then processed to a solid form for disposal.
c. The baseline value is taken from 1988 data for planned future activities.
d. These wastes are targeted for disposal at a federal repository.
e. Liquids containing transuranics are processed as HLW.
f. These wastes are targeted for disposal at WIPP.
g. Solidified or absorbed-liquid-waste quantities are included in the solid waste quantity.
h. Liquid effluents from sewage treatment operations.
i. Solids from sewage treatment operations.

Reductions in the volumes of radioactive wastes generated have been achieved through methods such as intensive surveying, waste segregation, recycling, and use of administration and engineering controls. Some examples of waste reduction follow:

- Waste minimization efforts have reduced the volume of waste water discharged to process trenches in the 300 Area by more than 5,600 cubic meters (>1.5 million gallons) per day. By the end of 1992, waste reduction efforts had reduced liquid waste by more than 22,000 cubic meters (>5.8 million gallons) (Woodruff and Hanf 1993).

- In 1991, 440,645 kilograms (971,440 pounds) of ferrous metals, 49,323 kilograms (108,737 pounds) of nonferrous metals, 275 cubic meters (9,076 cubic feet) of wood scrap, and 136,077 kilograms (299,993 pounds) of scrap paper were recycled. During 1992, approximately 181,440 kilograms (400,000 pounds) of paper were recycled (Woodruff and Hanf 1993).

On-going projects include packaging reduction, waste minimization design, and technology transfer.

Databases are used at the Hanford Site to track and manage waste management information. These databases have been screened to ensure that the information supplied is supported by official databases, reports, or other public documents. Although the most reliable data available have been used to quantify and characterize waste volumes, past waste volumes are imprecise and may be subject to change as characterization of previously disposed waste is undertaken and completed.

4.14.1 High-Level Waste

High-level radioactive waste is defined in the Nuclear Waste Policy Act of 1982 (PL 97-425) as "(A) the highly radioactive material resulting from the reprocessing of SNF, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and (B) other highly radioactive material that the [Nuclear Regulatory Commission], consistent with existing law, determines by rule requires permanent isolation."

High-level waste at Hanford was generated from the reprocessing of production reactor fuel for the recovery of plutonium, uranium, and neptunium for defense and other national programs of spent reactor fuel and irradiated targets. Radioactive waste generated on the Hanford Site from 1988 through 1990 is shown in Table 4.14-2.

4.14.1.1 Historic Overview. Until recently, the primary mission of the Hanford Site was production of special nuclear material for defense purposes. Since 1943, the Hanford Site has been involved in fabrication of reactor fuel elements, operation of production reactors, processing of irradiated fuel, separation and extraction of plutonium and uranium, preparation of plutonium metal, and decontamination and decommissioning activities. Between 1943 and 1964, 149 single-shell tanks were built to store liquid radioactive wastes. No new wastes have been added to these tanks since 1980; much of the liquid waste originally stored in the single-shell tanks has been transferred to some of the 28 one-million gallon double-shell tanks for safer storage (DOE 1993c).

Table 4.14-2. Radioactive waste generated on the Hanford Site from 1988-1990 in kilograms (excluding mixed waste).

Calendar Year	Low-Level Waste	Transuranic Waste	High-Level Waste
1988	3,800,000	21,900	0
1989	8,300,000	27,200	0
1990	3,600,000	24,500	0

Source: DOE 1991.

High-level waste has been accumulating at Hanford since 1944. Most of these high-level wastes have undergone one or more treatment steps (e.g., neutralization, precipitation, decantation, or evaporation) and will eventually require incorporation into a stable, solid medium (e.g., glass) for final disposal (DOE 1993d, 1992b).

Between 1956 and 1990, the Plutonium and Uranium Recovery through EXtraction (PUREX) plant processed irradiated reactor fuel to extract plutonium and uranium (DOE 1982). The wastes from the PUREX process were placed in double-shell tanks after 1970, and are the second high-level waste stream (DOE 1993c).

Cesium and Strontium Capsules: From 1968 to 1985, most of the high-heat emitting nuclides (strontium-90 and cesium-137, plus their daughters) were extracted from the old tank waste, converted to solids (strontium fluoride and cesium chloride), placed in double-walled metal cylinders (capsules) about 50 centimeters (20 inches) in length and 5 centimeters (2 inches) in diameter, which were stored in the Waste Encapsulation and Storage Facility in water-filled pools (DOE 1993d).

4.14.1.2 Current Status. There are two high-level waste streams at Hanford: the single-shell tank wastes and double-shell tank PUREX aging wastes. All wastes contained in double-shell tanks consist of mixtures of high-level wastes, transuranic waste, and several low-level wastes, and are managed as if they contain high-level waste. The single-shell tank wastes make up 95 percent of the Hanford Site high-level mixed waste (DOE 1993c).

There are currently 164,000 cubic meters (214,500 cubic yards) of wastes in the single-shell tanks, which are managed as high-level waste. The waste is multi-phased: most is sludge with interstitial liquids; some is in the form of crystalline solids, and there are some supernatant liquids present in the tanks. There are currently 92,000 cubic meters (120,000 cubic yards) of PUREX wastes in the double-shell tanks (DOE 1992e).

No known treatment is currently possible for these two waste streams, although it is planned to treat high-level wastes in the Hanford Waste Vitrification Plant, for which construction is scheduled to begin in 2002, with an operational start date in 2009 (DOE 1993c).

No high-level wastes are expected to be generated in 1995 from SNF management activities.

Cesium and Strontium Capsules: The total number of cesium capsules produced is 1,577. As of August 19, 1993, the number of known dismantled cesium capsules is 249; these have been put to beneficial use and are not expected to be returned. The total number of remaining capsules requiring disposal is 1,328. Of the 1,328 remaining capsules, 959 are in storage at Hanford, and 369 capsules have been leased for beneficial use. One of these capsules developed a small leak, and others have shown signs of bulging, so current plans are to bring all leased capsules back to the Hanford Site (DOE 1993d).

The total number of strontium capsules produced is 640. As of August 19, 1993, the number of known dismantled strontium capsules is 35; these have been put to beneficial use and are not expected to be returned. The total number of remaining capsules requiring disposal is 605. Of the 605, 601 are in storage at Hanford, and 4 have been leased offsite for beneficial use.

Therefore, at present 1,328 cesium capsules (2.47 cubic meters - 3.23 cubic yards) and 605 strontium capsules (1.08 cubic meters - 1.41 cubic yards) require storage. Nine-hundred and fifty-nine cesium capsules and 605 strontium capsules are stored in pools of water in the Waste Encapsulation and Storage Facility. The capsules will be stored at Hanford until they can be transported to a proposed national repository (DOE 1992d).

4.14.2 Transuranic Waste

Transuranic waste is defined in the Atomic Energy Act of 1954 (42 U.S.C. 2014[ee]) as "material contaminated with elements that have an atomic number greater than 92, including neptunium, plutonium, americium, and curium, and that are in concentrations greater than 10 nanocuries per gram, or in such other concentrations as the Nuclear Regulatory Commission may prescribe to protect the public health and safety."

Transuranic waste is primarily generated by research and development activities, plutonium recovery, weapons manufacturing, environmental restoration, and decontamination and decommissioning. Most transuranic waste exists in solid form (e.g., protective clothing, paper trash, rags, glass, miscellaneous tools, and equipment). Some transuranic waste is in liquid form (sludges) resulting from chemical processing for recovery of plutonium or other transuranic elements.

4.14.2.1 Historic Overview. Prior to 1970 all DOE-generated transuranic waste was disposed of onsite

in shallow, unlined trenches. From 1970 to 1986, transuranic wastes were segregated from other waste types and disposed in trenches designated for retrieval. Since 1986 all transuranic waste has been segregated and placed in retrievable storage pending shipment and final disposal in a permanent geologic repository (DOE 1992d, 1993g).

4.14.2.2 Current Status. Currently, all transuranic wastes are stored in above-grade storage

facilities in the Hanford Central Waste Complex and Transuranic Waste Storage and Assay Facility. The plan is to ship the stored transuranic waste to the Waste Isolation Pilot Plant near Carlsbad, New Mexico for final disposal.
The inventory of transuranic wastes is given in Table 4.14-3.

4.14.3 Mixed Low-Level Waste

Mixed low-level waste is defined as mixtures of low-level radioactive materials and (chemically and/or physically) hazardous wastes. Typically, mixed low-level waste includes a variety of contaminated materials, including air filters, cleaning materials, engine oils and grease, paint residues, photographic materials, soils, building materials, and decommissioned plant equipment.

Table 4.14-3. Transuranic waste inventory through 1991a.

Disposition of TRU Waste	Mass of TRU Nuclides (kilograms)	Volume (cubic meters)
Buried Waste	346	109,000b
Retrievable Storage	480	10,200

a. Source: DOE 1992d, Figures 3.3-3.6.
b. This number includes soils contaminated with TRUs.

4.14.3.1 Historic Overview. Between 1987 and 1991, 16,745 cubic meters (21,902 cubic yards) of mixed low-level waste were buried at the Hanford Site (between 1944 and 1986, no differentiation was made between low-level and low-level mixed wastes); all buried low-level wastes from that period are reported in subsection 4.14.4). Another 4,225 cubic meters (5,526 cubic yards) of mixed waste has been accumulating in storage in the Central Waste Complex, located in the 200-West Area (DOE 1993d).

The Hanford Site also receives defueled submarine reactor compartments, which are contaminated with PCBs and lead. These compartments are managed as mixed waste. Several compartments are received each year and placed in a trench in the 200-East Area (DOE 1993b).

4.14.3.2 Current Status. In 1992, 56,245 kilograms (124,000 pounds) of mixed low-level waste were generated. The 78 mixed low-level waste streams at Hanford make up 85,000 cubic meters (111,176 cubic yards) of waste (101,314,863 kilograms - 223,361,010 pounds). Ninety-six percent of the total is beta/gamma emitting waste in the form of mostly aqueous liquid in the double-shell tanks. One stream (double-shell tank miscellaneous waste) accounts for 40,000 cubic meters (52,318 cubic yards) of the mixed low-level wastes, and in combination, the double-shell tank Double-Shell Slurry Feed, double-shell tank Complex Concentrate and double-shell tank Double-Shell Slurry make up another 34,500 cubic meters (45,124 cubic yards). Three mixed low-level waste streams related to the 183-H Solar Evaporation Basin cleaning made up 2,500 cubic meters (3,270 cubic yards) of wastes. These inorganic sludge/particulate wastes have been neutralized and treated for packaging (DOE 1993c).

It is expected that of all the mixed low-level wastes at Hanford, 49 percent cannot be treated until the technology is modified or verified. The remaining 51 percent is to be processed through the 242A-Evaporator (a closed system in which distillates are passed through an ion-exchange system to remove cesium) (DOE 1993c).

In 1992, eight defueled submarine reactor compartment disposal packages were received and placed in Trench 94 of the 200-East Area Low-Level Waste Burial Grounds (Woodruff and Hanf 1993). The Naval Nuclear Propulsion Program will prepare an EIS for their proposal to bury additional reactor compartments at Hanford. As of November 1993, there were a total of 35 submarine reactor compartments stored in Trench 94.

Mixed low-level wastes generated in 1995 from SNF management activities will total 0.4 cubic meters (0.6 cubic yards).

4.14.4 Low-Level Waste

Low-level radioactive waste is defined in the Nuclear Waste Policy Act of 1982 (PL 97-425) as "radioactive material that (A) is not high-level radioactive waste, spent nuclear fuel, transuranic waste, or by-product material...; and (B) the [Nuclear Regulatory Commission], consistent with existing law, classifies as low-level radioactive waste." By-product material is defined in the Atomic Energy Act of 1954 [42 U.S.C. 2014(e)(2)] as "(1) any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material, and (2) the tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content."

Commercial fuel low-level waste can be generated by fuel fabrication and reactor operations. Low-level waste also results from commercial operations by private organizations that are licensed to use radioactive materials. These include institutions engaged in research and various medical and industrial activities. Some low-level waste is also generated by DOE environmental restoration activities. Other low-level wastes will be generated in future years by routine decommissioning and decontamination operations.

4.14.4.1 Historic Overview. From 1944 to 1991, approximately 558,916 cubic meters (731,034 cubic

yards) of low-level waste was buried at Hanford (DOE 1993d). Between 1944 and 1986, no differentiation was made between low-level and low-level mixed wastes - all data from that period are reported in this section. Another 130 cubic meters (170 cubic yards) was placed into storage.

U.S. Ecology operates a licensed commercial low-level waste burial ground at Hanford on a site that is leased to the State of Washington. Although physically located on the Hanford Site, it is not considered part of the Hanford facility. The site area is 40 hectares (99 acres), of which 29.5 hectares (72.9 acres) is considered usable, with 11.9 hectares (29.4 acres) used by the end of 1991. Through 1991 338,500 cubic meters (442,741 cubic yards) of low-level wastes had been disposed of at this site (DOE 1992d).

4.14.4.2 Current Status. Solid low-level waste currently is placed in unlined, near-surface trenches

at the 200-Area Low-Level Waste Burial Grounds. Onsite sources at the Hanford Site generated about 4500 square meters of low-level waste in 1992. Table 4.14-4 lists quantities of radioactive materials received at the Hanford Site from offsite generators over 5 years. The site continues to receive low-level waste from offsite generators for disposal. Major sources of this waste have been the Puget Sound Naval Shipyard in Washington, Brookhaven National Laboratory in New York, and Lawrence Berkeley Laboratory in California. Other points of origin include DOE facilities at nuclear power stations in Shippingport, Pennsylvania; Bechtel in Albany, Oregon; and Wood River in Charleston, Rhode Island (DOE 1993d). The U.S. Ecology commercial low-level burial ground continues to operate.

Table 4.14-4. Offsite low-level waste receipts summary (from 1987 through 1991).

Year	Volume (m3)	Activity (curies)
1987	7,000	68,000
1988	5,000	107,000
1989	600	1,500
1990	5,500	240,000
1991	5,300	489,000

a. Source: Draft Environmental Restoration and Waste Management Fiscal Year 1993 Site-Specific Plan for the Richland Field Office (DOE 1993d). (Does not include waste quantities received at the U.S. Ecology low-level burial ground.)

In 1995, 174.5 cubic meters (228.3 cubic yards) of low-level wastes will be generated from SNF management activities. Of this amount, 167.2 cubic meters (218.7 cubic yards) are contact handled, and 7.3 cubic meters (9.6 cubic yards) are remote handled.

4.14.5 Hazardous Waste

Hazardous waste is defined in the State of Washington Dangerous Waste Regulations (WAC 173-303) as solid waste designated by 40 CFR Part 261 and regulated as hazardous wastes by the EPA. The State of Washington designates wastes as either "dangerous waste" or "extremely hazardous waste." Hazardous wastes are generated during normal facility operations and environmental restoration activities at the Hanford Site (Table 4.14-5).

Mixed wastes are wastes that contain both hazardous waste (regulated under the Resource Conservation and Recovery Act) and radioactive waste (regulated under the Atomic Energy Act). The following special nuclear material production and site restoration activities have generated or may generate mixed waste:

- fabrication of reactor fuel elements
- operation of the production reactors
- processing of irradiated fuel
- separation and extraction of plutonium and uranium
- preparation of plutonium metal
- environmental restoration (i.e., soil and groundwater cleanup)
- research and development support projects
- maintenance and operations support.

Table 4.14-5. Hazardous waste generated on the Hanford Site from 1988 through 1992 (including mixed waste).

Calendar year	Hazardous waste (t)	Mixed waste (t)	Total (t)
1988	80,000	25,000	105,000
1989	66,000	9400	75,000
1990	780	12,000	13,000
1991	330	4600	4900
1992	620	3400	4000

Tank wastes constitute 99 percent of the mixed wastes at the Hanford Site. The Hanford Site currently has 233,689 cubic meters (305,654 cubic yards) of mixed wastes stored in these tanks: 145,952 cubic meters (190,898 cubic yards) of high-level waste, 3,935 cubic meters (5,147 cubic yards) of mixed transuranic waste, and 84,802 cubic meters (110,917 cubic yards) of mixed low-level waste. These wastes consist of 108 different waste streams (2 high-level waste, 22 mixed transuranic waste, and 84 mixed low-level waste). Of the 108 identified waste streams, 97 are still being generated. Additional environmental restoration waste streams are expected. Their numbers and types remain to be determined (DOE 1993c).

The Resource Conservation and Recovery Act components of mixed waste at the Hanford Site are mainly the following listed wastes: D002B (alkaline liquids, 22 streams), D006B (cadmium, 29 streams), D007 (chromium, 34 streams), D008B (lead, 30 streams), and F003 (nonchlorinated solvents, 30 streams). Waste sources are primarily the separations and extraction processes that were used to produce special nuclear material (DOE 1993c).

4.14.5.1 Historic Overview. In the past, hazardous waste generated at Hanford was either shipped

offsite, recycled, or treated onsite. Hazardous waste was also disposed of onsite (e.g., buried in trenches, burial grounds, or discharged to cribs or directly to the soil). For example, from 1943 through 1945, acids from a pipe-cleaning operation were discharged to the soil through two side-by-side cribs in an area west of the old White Bluffs townsite. From 1955 through 1973, approximately 379-2,271 cubic meters (100,000-600,000 gallons) of organic liquids, including carbon tetrachloride, were discharged to the soil in the 200-West Area. Drums containing approximately 19 cubic meters (5,000 gallons) of organic solvent (primarily hexone) were buried at the 618-9 burial ground north of the 300 Area. Many of these disposal sites have been or will be closed under RCRA or remediated under CERCLA (DOE 1993d).

4.14.5.2 Current Status. As of March 15, 1993, the Hanford Site contained 64 interim status treatment, storage, or disposal units. Present plans are that final RCRA permits will be sought for 24 of these 64 interim status treatment, storage, or disposal units. Thirty-four units will be closed under interim status. Six units will be dispositioned through other regulatory options. Future circumstances may cause these numbers to change. The treatment, storage, or disposal units within the Hanford facility include, but are not limited to, tank systems, surface impoundments, container storage areas, waste piles, landfills, and miscellaneous units. Other RCRA permits, such as research, development, and demonstration permits (for example, the 200-Area Liquid Effluent Treatment Facility), are also being pursued (DOE 1993d).

The principal present waste management practice for newly generated nonradioactive hazardous waste is to ship it offsite for treatment, recycling, recovery, and/or disposal. The Nonradioactive Dangerous Waste Storage Facility (616 Building) and the 305-B Waste Storage Facility are the only active facilities storing nonradioactive hazardous waste (other than less than 90-day storage areas) (DOE 1992d, 1993d), other than two boxes (one containing mixed and one containing nonradioactive waste) stored in the 222-S laboratory complex.

Hazardous wastes generated in 1995 from SNF management activities will total 2.2 cubic meters (2.9 cubic yards).

4.14.6 Industrial Solid Waste

Solid wastes are generated in all areas of the Hanford Site. Nondangerous solid wastes include the following nonradioactive, nonhazardous wastes:

(a) construction debris, office trash, cafeteria waste/garbage, empty containers, and packaging materials, medical waste, inert materials, bulky items such as appliances and furniture, solidified filter backwash and sludge from the treatment of river water, failed and broken equipment and tools, air filters, uncontaminated used gloves and other clothing, and certain chemical precipitates such as oxalates

(b) nonradioactive friable asbestos (regulated under the Clean Air Act)

(c) ash generated from powerhouses

(d) nonradioactive demolition debris from decommission projects.

4.14.6.1 Historic Overview. Both prior to and after establishment of the reservation, a number of landfills have been used on the Hanford Site for solid waste disposal, including the Horn Rapids, Central, Original Central, White Bluffs, East White Bluffs, Wahluke Slope and Hanford Townsite Landfills.

The active Hanford Site Solid Waste Landfill, located in the 200-Area, began operation in 1973. Nondangerous wastes in category (a) above are buried in the solid waste section of the Solid Waste Landfill, located in the 200-Area. Nonradioactive friable asbestos is buried in designated areas at the

Solid Waste Landfill. The nonradioactive dangerous waste section of the landfill was closed to chemicals in January 1985, and closed to asbestos in May 1988. Ash generated at powerhouses in the 200-East and 200-West Areas is buried in designated sites near those powerhouses. Demolition waste from 100-Area decommissioning projects is buried in situ or in designated sites in the 100 Areas (Woodruff and Hanf 1993; WHC 1993b). Solid waste has also been sent to the City of Richland landfill.

4.14.6.2 Current Status. In 1992, 22,213 cubic meters (29,054 cubic yards) of solid waste and 1,017 cubic meters (1,330 cubic yards) of asbestos were deposited in the solid waste section of the Solid Waste Landfill. Pit 10 was opened for disposal of inert material as defined in Washington Administrative Code (WAC) 173-304, and a total of 11,389 cubic meters (14,986 cubic yards) were disposed of there. A summary of the solid waste disposed of at the Hanford Site from 1973 through 1992 is shown in Table 4.14-6. The landfill is currently scheduled for closure in 1997 (WHC 1993b). Quantities of solid waste disposed of at the City of Richland Landfill are not readily available.

4.14.7 Hazardous Materials

A hazardous chemical is any chemical that poses a physical or health hazard [as defined in 29 CFR 1900.1200(c)]. The Emergency Planning and Community Right-to-Know Act sets forth reporting requirements (Tier 1 and Tier 2) that provide the public with information on hazardous chemicals to enhance community awareness of chemical hazards and facilitate the development of state and local emergency response plans.

Table 4.14-6. 1973-1992: Historical annual volume of onsite buried solid sanitary waste in cubic meters per year.

Waste Type	Volume (m3/year)											
	73-81	82	83	84	85	86	87	88	87	90	91	92
Construction Debris[a]	4,149	5,819	9,494	10,378	10,789	14,254	14,316	12,842	12,469	10,088	5,666	7,330
Metals[b]	1,383	1,940	3,165	3,459	3,596	4,751	4,772	4,281	4,156	3,363	1,889	2,443
Paper	5,658	7,936	12,946	14,151	14,712	19,437	19,522	17,512	17,003	13,757	7,727	9,996
Miscellaneous[c]	1,383	1,940	3,165	3,459	3,569	4,751	4,772	4,281	4,156	3,363	1,889	2,443
Total	12,573	17,635	28,770	31,447	32,694	43,193	43,382	38,916	37,785	30,571	17,170	22,213

a. Construction Debris: Volume is calculated based on disposal volume (excluding asbestos) at the onsite landfill: Construction debris 33 percent; Metals 11 percent, Paper 45 percent, Miscellaneous Waste 11 percent.
b. Metals: See note b above. Category consists of large bulky items such as appliances and furniture.
c. Miscellaneous: Category includes garbage, packaging, empty containers, medical waste and inert materials.

4.14.7.1 Historic Overview. Hazardous chemicals are used throughout the Hanford Site in facility and environmental restoration operations. The types of chemicals in inventory onsite tend to be static since Hanford's mission involves mainly remediation and decontamination and decommissioning (as opposed to production or processing). The amount of chemicals actually onsite changes from day to day, and there is no requirement to keep a real- time inventory of the quantity of chemicals onsite at any one time. Also, the percentage of hazardous chemicals used onsite that eventually become hazardous waste cannot be determined.

4.14.7.2 Current Status. The Hazardous Materials Inventory Database currently being used to generate

Tier 2 data indicates that approximately 1484 hazardous chemicals are reported in inventory at over 783 locations on the Hanford Site. These 1484 chemicals are contained in approximately 2926 different hazardous materials, in weights that range from less than 0.5 kilograms (one pound) to a maximum inventory of 35,658,872 kilograms (78,614,420 pounds).

The DOE has prepared chemical inventory reports required by the Emergency Planning and Community Right-to-Know Act since 1988 (for calendar year 1987). In 1992 the Emergency Planning and Community Right-to-Know Act reporting threshold was exceeded for 53 hazardous chemicals.

5. ENVIRONMENTAL CONSEQUENCES

Descriptions of analyses for various potential environmental consequences as a result of implementing 1) No Action, 2) Decentralization, 3) 1992/1993 Planning Basis, 4) Regionalization, and 5) Centralization Alternatives for interim storage of SNF for the Hanford Site are presented in the following subsections. By and large these discussions are at the programmatic level because in many cases specific alternative treatments and locations, particularly for new facilities, have not been identified for the Hanford Site.

5.1 Overview

An overview of the various alternatives and a brief summary of potential environmental consequences of interest are provided in the following subsections. For purposes of this programmatic analysis, all new facilities were assumed to be constructed in a quarter section of land adjacent to the 200-East Area; commitment of that amount of land within the industrialized 200 Areas would be consistent with the site mission and would not represent a conflict on land use. Up to 15 percent of that area would be disturbed during construction of storage and support facilities where required. A survey of the area described revealed no threatened and endangered species or cultural resources. Routine operations under any of the alternatives would not add significantly to current occupational or near-zero public exposure to radiation. Although not quantified, no significant additions to current releases of criteria pollutants or other hazardous materials would be expected from implementing any of the alternatives. However, such implementation requires a small increase in Hanford's electrical power consumption; the largest increase would be less than 1.5 percent. The influx of workers would probably increase competition for desirable housing and strain teacher/student ratios in some local school districts, the extent of which (although small in any case) would depend on the option chosen.

5.1.1 No Action Alternative

The No Action Alternative identifies the minimum actions deemed necessary for continued safe and secure storage of SNF at the Hanford Site. Upgrade of the existing facilities would not occur other than as required to ensure safety and security. No receipt of fuels from offsite would occur. No research and development would take place; however, characterization of fuel would continue to establish a safety envelope for extended interim storage, fuel would be containerized at the 105-KE Basin, and the first 10 dry storage casks would be procured for FFTF fuel.

Results presented in the Hanford Site Environmental Report for 1992 (Woodruff and Hanf 1993) suggest that under normal conditions no significant environmental effects would be associated with the No Action Alternative. For example, the radiation dose to the maximally exposed individual in the Hanford environs from all Hanford sources was calculated to have been 0.02 mrem and the collective population dose was 0.8 person-rem during 1992. Continued storage of SNF contributed only a small portion of those doses. No health effects would be expected as a result of such small doses. For perspective, the Hanford Site doses for 1992 may be compared to annual individual doses of 300 mrem and an annual collective dose of about 100,000 person-rem from natural background radiation.

5.1.2 Decentralization Alternative

The Decentralization Alternative would consider additional facility upgrades over those considered in the No Action Alternative, specifically, new wet storage (for defense production fuel only) or dry storage facilities, fuel stabilization via shear/leach/calcination or shear/leach/ solvent extraction, with research and development activities to support SNF management.

Impacts from storage prior to implementation of new wet or dry storage or fuels stabilization would not differ from those indicated for the No Action Alternative. In the event new storage facilities are selected some impacts would be associated with construction of those facilities. A proposed site has been identified comprising one-quarter section of land adjacent to the 200-East Area where any new facilities associated with SNF storage or stabilization that might be necessary would be assumed to be built. The area has been surveyed both for threatened and endangered species and for the presence of cultural resources; none were found. However, one federal candidate species, the loggerhead shrike, and one state candidate species, the sage sparrow, were seen. Use of this area is consistent with the Hanford mission and would impact no threatened or endangered biota. Construction would take place on up to 15 percent of the selected site. Construction activities would result in dust generation and various amounts of pollutants released from diesel-fueled equipment; however, concentrations at points of public access are expected to be well below permissible levels. Impacts associated with SNF storage would be expected to be less than those in the No Action Alternative.

Research and development of technologies for SNF stabilization would be undertaken in existing hot cell facilities in the 300 Area. Although not examined in detail for this programmatic analysis, no important environmental consequences have resulted from work in these facilities and none would be anticipated for development activities related to fuel processing.

5.1.3 1992/1993 Planning Basis Alternative

The 1992/1993 Planning Basis Alternative differs from the Decentralization Alternative only in that TRIGA fuel currently stored at the Hanford Site would be shipped to INEL for storage. The storage and stabilization options identified for the Decentralization Alternative are also assumed for the 1992/93 Planning Basis Alternative and that discussion is not repeated here. The potential impacts of transportation of TRIGA fuel to INEL are covered in Appendix I.

5.1.4 Regionalization Alternative

The Regionalization Alternative as it applies to the Hanford Site contains the following options:

A) All SNF, except defense production SNF, would be sent to INEL.

B1) All SNF west of the Mississippi River, except Naval SNF would be sent to Hanford.

B2) All SNF west of the Mississippi River and Naval SNF would be sent to Hanford.

C) All Hanford SNF would be sent to INEL or Nevada Test Site (NTS).

Facilities and features of Regionalization A would be the same as those described for Hanford defense production fuel in the Decentralization Alternative. The facilities and features for all other Hanford SNF would be very similar to those described for that spent nuclear fuel in the Centralization Minimum Alternative.

Facilities and features of Regionalization B1 and B2 options would be incremental to those described for the Decentralization Alternative and would be similar, but not identical, to those described in the Centralization Maximum Alternative.

Facilities and features of Regionalization C would be equivalent to those described for the Centralization Minimum Alternative.

5.1.5 Centralization Alternative

Two options exist at the Hanford Site for the Centralization Alternative: 1) shipment of all fuel within the DOE complex to the Hanford Site for management and storage, and 2) shipment of all fuel off of the Hanford Site. In the former option, dry storage of all fuel sent to the Hanford Site from offsite would be assumed. A facility equivalent to the decentralization sub-options would be assumed for processing of SNF prior to storage; fuel received from offsite would have been stabilized for dry storage prior to receipt. The consequences of implementing this option would be larger than those of the Decentralization Alternative. In the option of transferring all Hanford fuel to another site, a fuel stabilization and packaging facility would need to be constructed to prepare existing fuel for shipment.

5.2 Land Use

Implications of implementing the alternatives for interim storage of SNF on land use at the Hanford Site are discussed in the following subsections.

5.2.1 No Action Alternative

No new SNF facilities would be built at the Hanford Site; thus, land use patterns would remain as described in Section 4.2 and have no impact on the existing environment. The Hanford Site would remain a federal facility dedicated to nuclear research and development and environmental cleanup. Other continuing activities would include waste management, commercial power production, ecological research, and wildlife management, as described in Section 4.2.

5.2.2 Decentralization Alternative

This alternative would require the construction of an SNF facility for fuel management and storage. Most SNF from the Hanford Site would be stored at that facility.

Historically, the Hanford Site has been used for nuclear materials production. The construction and operation of an SNF facility would be consistent with this historical use. Off-site land use would not be affected by construction and operations of an SNF facility, except to the extent that some undeveloped lands probably would be developed for worker housing. Such development would be subject to local land use and zoning controls, which vary by jurisdiction. No project facilities would be located offsite.

No direct or indirect effects would occur to wildlife refuges on the Hanford Site because SNF activities would not be close to these areas. Similarly, no direct or indirect effects would occur to the Columbia River. Although construction at the SNF site would disturb native vegetation (Section 5.9.1), on up to 7 hectares (18 acres) of the 65-hectare (160-acre) site, this would involve only a small part of similar natural habitat at Hanford. The use of Hanford as a National Environmental Research Park would not be significantly affected.

No impacts requiring mitigation would occur to land uses a result of construction or operation of an SNF facility at the Hanford Site.

5.2.3 1992/1993 Planning Basis Alternative

The 1992/1993 Planning Basis Alternative differs from the Decentralization Alternative only in that TRIGA fuel currently stored at the Hanford Site may be shipped to INEL for storage. Thus, land use would be essentially the same as in the Decentralization Alternative. Although construction at the SNF site would disturb native vegetation (Section 5.9.1), on up to 7 hectares (18 acres) of the 65-hectare (160-acre) site, this would involve only a small part of similar natural habitat at Hanford. The use of Hanford as a National Environmental Research Park would not be significantly affected.

5.2.4 Regionalization Alternative

Construction of facilities in support of the Regionalization Alternative as it applies to the Hanford Site would result in the following disturbance of native vegetation and land use commitments:

A) From about 2 to 7 hectares (6 to 18 acres) when all SNF, except defense production SNF would be sent to INEL.

B1) From about 14 to 17 hectares (36 to 43 acres) when all SNF west of the Mississippi River, except Naval SNF would be sent to Hanford.

B2) From about 24 to 27 hectares (61 to 68 acres) when all SNF west of the Mississippi River and Naval SNF would be sent to Hanford.

C) From about 2 to 5 hectares (6 to 12 acres) when all Hanford SNF would be sent to INEL or NTS.

These areas involve only a small part of similar natural habitat at Hanford. The use of Hanford as a National Environmental Research Park would not be significantly affected.

5.2.5 Centralization Alternative

If Hanford is selected as the site for implementing the Centralization Alternative, the SNF facility and its support facilities (including a new Expended Core Facility) would be constructed. The impacts of such construction would be essentially the same as those presented for the Decentralization Alternative. Although construction at the SNF site would disturb native vegetation (Section 5.9.1) on up to 37 hectares (93 acres) of the 65-hectare (160-acre) site, this would involve only a small part of similar natural habitat at Hanford. In addition to the above total, new construction would also include construction of a new Expended Core Facility for fuel from the Naval Nuclear Propulsion Program. The use of Hanford as a National Environmental Research Park would not be significantly affected.

If Hanford is not selected as the site for centralization of SNF, an SNF stabilization and packaging facility would be built to prepare the fuel for transport offsite. This facility would have somewhat smaller construction requirements than would be required for storage of all DOE SNF at Hanford. The land use impacts would be similar to those described for the Regionalization option C.

5.2.6 Effects of Alternatives on Treaty or Other Reserved Rights of Indian

Tribes and Individuals

The Yakama Indian Nation and the Confederated Tribes of the Umatilla Indian Reservation acquired certain rights and privileges in the 1855 treaty. These rights and privileges are also claimed by the Wanapum Tribe. In Article III, of the 1855 treaty it states that "The exclusive right of taking fish in all streams, where running through or bordering said reservation, is further secured to said confederated tribes and bands of Indians, as also the right of taking fish at all usual and accustomed places, in common with citizens of the

Territory, and of erecting temporary buildings for curing them; together with the privilege of hunting, gathering roots and berries, and pasturing their horses and cattle upon open unclaimed land.(a)"

Although access to the Hanford Site has been restricted, tribal members have expressed an interest in renewing their use of these resources in accordance with the Treaty of 1855, and the DOE is assisting them in this effort. In keeping with this effort, each of the alternatives would provide for the rights and privileges identified in the treaty:

- Taking Fish - The alternatives considered in this document would not reduce access to fishing locations on the Hanford Site.

- Hunting, Gathering Roots and Berries, and Pasturing Livestock - The No Action Alternative would not further reduce the areas potentially available for hunting, gathering roots and berries, or pasturing livestock. All existing fenced areas assigned for SNF storage and a suitable buffer zone would likely remain unavailable for these activities. All other alternatives would require the construction of new facilities. This would further reduce the land base available for hunting, gathering, and pasturing. This impact could be on the order of 18 acres.

5.3 Socioeconomics

The following section describes the socioeconomic impacts of the SNF project at the Hanford Site. For the analysis, a ten-county region of influence was identified. While the region of influence covers the counties of Adams, Benton, Columbia, Franklin, Grant, Walla Walla, and Yakima in the state of Washington; and Morrow, Umatilla, and Wallowa counties in the state of Oregon, the majority of the impacts would be confined to the Benton-Franklin County region and the Tri-Cities (Richland, Kennewick, and Pasco) (see Figure 4-2).

The socioeconomic impacts are classified in terms of direct and secondary effects. Changes in Hanford employment and expenditures are classified as direct effects, while changes that result from Hanford regional purchases, nonpayroll expenditures, and payroll spending by Hanford employees are classified as secondary effects. The total socioeconomic impact within the region is the sum of the direct and secondary effects.

Estimates of total employment impacts were calculated using the Regional Input-Output Modeling System developed for the Hanford region of influence by the U.S. Bureau of Economic Analysis. This assessment reports the changes in employment and earnings based on historic data, which indicate that 93 percent of Hanford employees reside in the Benton-Franklin county area. Table 4.3-1 in Section 4.3 presents the baseline projections from which comparisons can be made.

All employment comparisons are made relative to the regional employment projections and not current Hanford Site employment projections. While a down-turn in Hanford Site employment is anticipated, the extent of the down-turn is unknown. The effect of such a down-turn on the region's employment projection used in this analysis is expected to be minimal because the regional projection, released in 1992, assumed a more stable rate of growth than the actual "boom" experienced in recent years.

5.3.1 No Action Alternative

Under the No Action Alternative, only the minimum actions required for continued safe and secure storage of SNF would occur. No new facilities would be constructed, and only minimal facility upgrades would take place. It is assumed that existing personnel would be utilized under this alternative, and therefore no incremental socioeconomic consequences are anticipated. Socioeconomic conditions would continue as described in Section 4.3.

5.3.2 Decentralization Alternative

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a. These treaty rights and priviledges are subject to diverse interpretations. None of the lands contemplated for use for SNF processing and/or storage at Hanford were on "open unclaimed land" when the government established the Hanford Site.

Under the Decentralization Alternative, significant facility development and upgrades are permitted, with various suboptions defined for processing and storage of the SNF. The socioeconomic consequences related to implementing the decentralization alternatives are described in this subsection. The employment and population impacts related to construction and operation of the Decentralization Alternative suboptions are presented in Table 5.3-1. It was assumed that up to 300 current Hanford workers could be reassigned to operation activities (this number excludes current workers at the Fast Flux Test Facility because it was assumed that they would be reassigned to activities related to the Hanford Waste Vitrification Plant). Construction activities were assumed to require new workers coming into the area. Estimates of direct jobs were provided by Bergsman (1995). For construction activity, direct jobs were reported as number of jobs in the peak year and total person-years because it was assumed that construction activities would "ramp-up" to the peak year, and then "ramp-down," with the total number of jobs related to construction activity equaling the total person-years required, as reported in Bergsman (1995). Increases in activity levels could strain an already tight housing market and add to school-capacity concerns. However, because construction activities are short-term relative to the total project time frame, impacts from construction activities may be overstated.

5.3.2.1 Employment. All construction activity is assumed to peak in

1998. Construction activity for storage options W, X, Y, and Z occurs in the years 1997-2000; construction activity for processing suboptions P and Q occurs in the years 1998-2001. Increases in employment range from 221 (suboption X) to 1,094 (suboptions Y and P) and equate to between 0.3 and 1.3 percentage points over baseline regional employment projections (see **Table 4.3-1).** All operations activity peaks in 2002, with incremental activity tapering off. Increases in employment range from 442 (suboptions Z and P) to 880 (suboptions Q and Small Vault) persons and equate to between 0.5 and 1.0 percentage points over baseline regional employment projections. Beyond 2004, operations activity will taper off as processing activities (suboptions P and Q) will occur only through 2005. Suboptions Y and Z each require only 50 workers beyond 2005 for operations activity. Because it is anticipated that up to 300 current workers could be reassigned, no incremental socioeconomic impacts are anticipated after 2005. This is also true with suboptions W and X because they are assumed to absorb between 200 and 210 current workers for the first two years of operation (2001-2002), with employment requirements falling to between 150 and 95

Table 5.3-1. Comparison of the socioeconomic impacts of spent nuclear fuel Decentralization Alternative suboptions.

Decentralization Alternative	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Suboption W										
Direct Jobs	0	0	216	251	216	181	0	0	0	0
Secondary Jobs	0	0	240	280	240	200	0	0	0	0
Population Change	0	0	590	680	590	490	0	0	0	0
Suboption X										
Direct Jobs	0	0	200	221	200	178	0	0	0	0
Secondary Jobs	0	0	220	240	220	200	0	0	0	0
Population Change	0	0	540	600	540	490	0	0	0	0
Suboptions Y and P										
Direct Jobs	0	0	318	1,094	1,033	971	715	464	464	464
Secondary Jobs	0	0	350	1,200	1,130	1,070	780	590	590	590
Population Change	0	0	870	2,980	2,810	2,650	1,950	1,370	1,370	1,370
Suboptions Q and Small Vault										
Direct Jobs	0	0	62	947	934	920	872	880	880	880
Secondary Jobs	0	0	70	1,040	1,020	1,010	960	1,120	1,120	1,120
Population Change	0	0	170	2,580	2,540	2,510	2,380	2,610	2,610	2,610
Suboptions Z and P										
Direct Jobs	0	0	213	935	926	920	715	442	442	442

Secondary Jobs	0	0	230	1,030	1,020	1,010	780	570	570	570
Population Change	0	0	580	2,550	2,530	2,510	1,950	1,310	1,310	1,310
Suboptions Q and Cask										
Direct Jobs	0	0	45	917	917	917	872	822	822	822
Secondary Jobs	0	0	50	1,010	1,010	1,010	960	1,050	1,050	1,050
Population Change	0	0	120	2,500	2,500	2,500	2,380	2,430	2,430	2,430

workers in 2003 and 2004. For the remaining years (2005-2035), suboptions W and X each would require only 60 workers for operation activities.

5.3.2.2 Population. For construction-related activities, the

population is expected to peak in 1998, with increases in population ranging from 600 (suboption X) to 2,810 (suboptions Y and P) and equating to between 0.4 and 1.7 percentage points over baseline projections (see Table 4.3-1). All operations activity peaks in 2002, with incremental activity tapering off through 2007. Increases in population range from 1,310 (suboptions Z and P) to 2,610 (suboptions Q and Small Vault) persons and equate to between 0.7 and 1.5 percentage points over baseline projections for 2002.

5.3.3 1992/1993 Planning Basis Alternative

This alternative defines those activities that were already scheduled at the various sites for the transportation, receipt, processing, and storage of SNF. Under this alternative, no new spent fuel would be sent to the Hanford Site, but the TRIGA fuel would be shipped offsite. The upgrades of existing storage facilities, as defined in the Decentralization alternative, were already planned, so the impacts of the 1992/1993 Planning Basis Alternative are essentially the same as outlined in Subsection 5.3.2. Because of the shipment of TRIGA fuel, an additional two workers per year would be required over 3 years of operation; however, it was assumed that current personnel would be reassigned to fill these jobs; therefore, the incremental impacts would be the same as those presented in Table 5.3-1.

5.3.4 Regionalization Alternative

Under this alternative, SNF would be redistributed to candidate sites based on similarity of SNF types or region within the country. There are four possible cases: regionalization of SNF by fuel type (Regionalization A); regionalization in which all SNF currently stored in the western United States, or to be generated in the western United States, except Naval SNF would be sent to and stored at the Hanford Site (Regionalization B1); regionalization in which all SNF currently stored in the western United States, or to be generated in the western United States, and all Naval fuel would be sent to and stored at the Hanford Site (Regionalization B2); and regionalization in which all SNF currently located in the western United States, or to be generated in the western United States, including all Hanford SNF, would be sent to and stored at another location (Regionalization C).

5.3.4.1 Regionalization A. In this case, all SNF currently located at

Hanford, except defense production fuel, would be sent to INEL. For the Hanford Site, the facility requirements for the N reactor and single-pass reactor fuel would be the same as those described in the Decentralization Alternative. Facilities for all other Hanford Site fuel would be similar to those described within the Centralization minimum alternative. The population and employment impacts related to Regionalization A are presented in Table 5.3-2.

5.3.4.1.1 Employment.

All construction activity is assumed to peak in 1998. Construction activity for suboptions RAX, RAY, and RAZ occurs in the years 1997-2000 and construction activity for suboption P occurs in the years 1998-2001. Increases in employment range from 176 (suboption RAX) to 1,065 (suboption RAY and P) and equate to between 0.2 and 1.3 percentage points over baseline projections of regional employment (see Table 4.3-1). All operations activity peaks in 2002, with incremental activity tapering off. Increases in employment range from 208 (suboption RAY and P) to 230 (suboption RAZ and P) persons and equate to between 0.2 and 0.3 percentage points over baseline projections. Beyond 2004, operations activity will taper off as processing activities (suboption P) will only occur through 2005. Suboptions RAY and RAZ each require only 50 workers beyond 2005 for operations activity. Because it is anticipated that up to 300 current workers could be reassigned, no incremental socioeconomic impacts are anticipated after 2005. This is also true with suboption RAX because it would require only 59 workers for operation activities after 2005.

5.3.4.1.2 Population.

For construction-related activities, the population is expected to peak in 1998, with increases in population ranging from 480 (suboption RAX) to 2,900 (suboption RAY and P) and equating to between 0.3 and 1.7 percentage points over baseline projections (see Table 4.3-1). All operations activity peaks in 2002, with incremental activity tapering off through 2006. Increases in population range from 620 (suboption RAX) to 680 (suboption RAY and P) persons and equate to between 0.3 and 0.4 percentage points over baseline projections for 2002.

Table 5.3-2. Comparison of socioeconomic impacts of spent nuclear fuel Regionalization A suboptions.

Regionalization A Suboptions	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Suboption RAX										
Direct Jobs	0	0	90	176	176	176	0	0	0	0
Secondary Jobs	0	0	100	190	190	190	0	0	0	0
Population Change	0	0	250	480	480	480	0	0	0	0
Suboption RAY and P										
Direct Jobs	0	0	150	1,065	1,065	1,065	715	208	208	208
Secondary Jobs	0	0	160	1,170	1,170	1,170	780	270	270	270
Population Change	0	0	410	2,900	2,900	2,900	1,950	620	620	620
Suboption RAZ and P										
Direct Jobs	0	0	150	865	865	865	715	230	230	230
Secondary Jobs	0	0	160	950	950	950	780	290	290	290
Population Change	0	0	410	2,360	2,360	2,360	1,950	680	680	680

5.3.4.2 Regionalization B1. In this case, all SNF currently stored or

to be generated in the western United States, except Naval SNF, would be sent to and stored at the Hanford Site. Facility requirements for this case would be incremental to those described for the Decentralization Alternative. Additional facilities include a storage facility for offsite fuel, a receiving and canning facility, and a technology development facility (RB1). The population and employment impacts related to regionalization B1 are presented in Table 5.3-3.

5.3.4.2.1 Employment.

All construction activity is assumed to peak in 2000. Construction activity for suboptions W, X, Y, and Z occurs in the years 1997-2000; construction activity for suboptions P and Q occurs in the years 1998-2001; and construction of the additional facilities (suboption RB1) for receiving and canning and technology development occurs in the years 1998-2001, with 90% of the storage facility being constructed during the years 2000-2010 and the remaining 10% being constructed during the years 2010-2035. Increases in employment range from 398 (suboption X and RB1) to 1,191 (suboption Y and P and RB1) and equate to between 0.5 and 1.4 percentage points over baseline projections of regional employment (see Table 4.3-1). All operations activity peaks in 2002, with incremental activity tapering off. Increases in employment range from 73 (suboption X and RB1) to 1,050 (suboption Q and Small Vault and RB1) persons and equate to between 0.1 and 1.2 percentage points over baseline projections. Beyond 2004, operations activity will taper off as described in Section 5.3.2.2.1.

5.3.4.2.2 Population.

For construction-related activities, the population is expected to peak in 2000, with increases in population ranging from 1,090 (suboptions W and RB1 and X and RB1) to 3,250 (suboption Y and P and RB1) and equating to between 0.6 and 1.9 percentage points over baseline projections (see Table 4.3-1). All operations activity peaks in 2002, with incremental activity tapering off through 2006. Increases in population range from 200 (suboptions X and RB1) to 3,100 (suboptions Q, Small Vault, and RB1) persons and equate to between 0.1 and 1.7 percentage points over baseline projections for 2002.

5.3.4.3 Regionalization B2. In this case, all fuel currently stored or

to be generated in the western United States, including Naval fuel, would be sent to and stored at the Hanford Site. Facility requirements for this case would be essentially the same as those described in the Regionalization B1 case, as the only difference would be the presence of Naval fuel. The receiving and canning facility, offsite storage facility, and technology development facility are referred to as suboption RB2. Also required for this case is the Naval Nuclear Propulsion

Table 5.3-3. Comparison of socioeconomic impacts of spent nuclear fuel Regionalization B1 suboptions.

Regionalization B1 Suboption	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Suboptions W and RB1										
Direct Jobs	0	0	216	381	352	401	215	75	72	72
Secondary Jobs	0	0	240	420	390	440	240	80	80	80
Population Change	0	0	590	1,040	960	1,090	590	210	200	200
Suboptions X and RB1										
Direct Jobs	0	0	200	351	336	398	215	73	72	72
Secondary Jobs	0	0	220	390	370	440	240	80	80	80
Population Change	0	0	540	960	910	1,090	590	200	200	200
Suboptions Y, P, and RB1										
Direct Jobs	0	0	318	1,224	1,169	1,191	930	637	636	636
Secondary Jobs	0	0	350	1,340	1,280	1,310	1,020	800	800	800
Population Change	0	0	870	3,340	3,180	3,250	2,530	1,870	1,870	1,870
Suboptions Z, P, and RB1										
Direct Jobs	0	0	213	1,065	1,064	1,140	930	615	614	614
Secondary Jobs	0	0	230	1,170	1,170	1,250	1,020	770	770	770
Population Change	0	0	580	2,900	2,900	3,110	2,530	1,800	1,800	1,800
Suboptions Q, Small Vault, and RB1										

Direct Jobs	0	0	62	1,077	1,070	1,140	1,090	1,050	1,050	1,050
Secondary Jobs	0	0	70	1,180	1,170	1,250	1,190	1,330	1,330	1,330
Population Change	0	0	170	2,940	2,920	3,110	2,960	3,100	3,100	3,100
Suboptions Q, Cask, and RB1										
Direct Jobs	0	0	45	1,047	1,053	1,137	1,087	995	994	994
Secondary Jobs	0	0	50	1,150	1,150	1,250	1,190	1,260	1,260	1,260
Population Change	0	0	120	2,850	2,870	3,100	2,960	2,930	2,930	2,930

Program's Expended Core Facility (ECF). Discussion on the relocation of the ECF to the Hanford Site is provided in Appendix D to the INEL Spent Nuclear Fuel PEIS and is not included here. Population and employment impacts of the Regionalization B2 case are presented in Table 5.3-4.

5.3.4.3.1 Employment.

All construction activity is assumed to peak in 2000. Construction activity for suboptions W, X, Y, and Z occurs in the years 1997-2000; construction activity for suboptions P and Q occurs in the years 1998-2001; and construction of the additional facilities (suboption RB1) for receiving and canning and technology development occurs in the years 1998-2001, with 35% of the storage facility being constructed during the years 2000-2010 and the remaining 65% being constructed during the years 2010-2035. Increases in employment range from 488 (suboptions X and RB2) to 1,281 (suboptions Y, P, and RB2) and equate to between 0.6 and 1.5 percentage points over baseline projections of regional employment (see Table 4.3-1). All operations activity peaks in 2002, with incremental activity tapering off. Increases in employment range from 80 (suboptions X and RB2) to 1,085 (suboptions Q, Small Vault, and RB2) persons and equate to between 0.1 and 1.3 percentage points over baseline projections. Beyond 2004, operations activity will taper off as described in section 5.3.2.2.1.

5.3.4.3.2 Population.

For construction-related activities, the population is expected to peak in 2000, with increases in population ranging from 1,330 (suboptions X and RB2) to 3,490 (suboptions Y, P and RB2) and equating to between 0.8 and 2.0 percentage points over baseline projections (see Table 4.3-1). All operations activity peaks in 2002, with incremental activity tapering off through 2006. Increases in population range from 220 (suboption X and RB2) to 3,190 (suboptions Q, Small Vault, RB2) persons and equate to between 0.1 and 1.8 percentage points over baseline projections for 2002.

5.3.4.4 Regionalization C. In this case, all fuel currently stored or to be generated in the western United States, including all Hanford Site fuel, would be sent to and stored at INEL or NTS. Facility requirements for the Hanford Site in this case are identical to those described in the Centralization Minimum Alternative. Employment and population impacts of this case are provided in Table 5.3-5 and are discussed in Section 5.3.5.2.

Table 5.3-4. Comparison of socioeconomic impacts of spent nuclear fuel Regionalization B2 suboptions.

Regionalization Alternative	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Suboptions W and RB2										
Direct Jobs	0	0	216	451	446	491	310	107	80	80
Secondary Jobs	0	0	240	490	490	540	340	120	90	90
Population Change	0	0	590	1,230	1,220	1,340	850	300	220	220
Suboptions X and RB2										
Direct Jobs	0	0	200	421	430	488	310	80	80	80

Secondary Jobs	0	0	220	460	470	540	340	90	90	90
Population Change	0	0	540	1,150	1,170	1,330	850	220	220	220
Suboptions Y, P, and RB2										
Direct Jobs	0	0	318	1,294	1,263	1,281	1,025	669	669	669
Secondary Jobs	0	0	350	1,420	1,380	1,400	1,120	840	840	840
Population Change	0	0	870	3,530	3,440	3,490	2,790	1,960	1,960	1,960
Suboptions Z, P, and RB2										
Direct Jobs	0	0	213	1,135	1,158	1,230	1,025	647	647	647
Secondary Jobs	0	0	230	1,240	1,270	1,350	1,120	810	810	810
Population Change	0	0	580	3,090	3,150	3,350	2,790	1,900	1,900	1,900
Suboptions Q, Small Vault and RB2										
Direct Jobs	0	0	62	1,147	1,164	1,230	1,182	1,085	1,085	1,085
Secondary Jobs	0	0	70	1,260	1,280	1,350	1,300	1,370	1,370	1,370
Population Change	0	0	170	3,130	3,170	3,350	3,220	3,190	3,190	3,190
Suboptions Q, Cask, and RB2										
Direct Jobs	0	0	45	1,117	1,147	1,227	1,182	1,027	1,027	1,027
Secondary Jobs	0	0	50	1,230	1,260	1,350	1,300	1,300	1,300	1,300
Population Change	0	0	120	3,040	3,130	3,340	3,220	3,020	3,020	3,020

Table 5.3-5. Comparison of socioeconomic impacts of spent nuclear fuel Centralization Alternative - maximum case suboptions.

Centralization Alternative	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Suboptions W and CM										
Direct Jobs	0	0	216	626	606	611	430	242	193	193
Secondary Jobs	0	0	240	690	660	670	470	280	220	220
Population Change	0	0	590	1,710	1,650	1,670	1,170	680	540	540
Suboptions X and CM										
Direct Jobs	0	0	200	596	590	608	430	164	135	135
Secondary Jobs	0	0	220	650	650	670	470	180	150	150
Population Change	0	0	540	1,620	1,610	1,660	1,170	450	360	360
Suboptions, Y, P, and CM										
Direct Jobs	0	0	318	1,469	1,423	1,401	1,145	804	804	804
Secondary Jobs	0	0	350	1,610	1,560	1,540	1,260	1,000	1,000	1,000
Population Change	0	0	870	4,000	3,880	3,820	3,120	2,350	2,350	2,350
Suboptions Z, P, and CM										
Direct Jobs	0	0	213	1,310	1,318	1,350	1,145	782	782	782
Secondary Jobs	0	0	230	1,440	1,440	1,480	1,260	970	970	970
Population Change	0	0	580	3,570	3,590	3,680	3,120	2,280	2,280	2,280
Suboptions Q, Small Vault, and CM										
Direct Jobs	0	0	62	1,322	1,324	1,350	1,302	1,220	1,220	1,220
Secondary Jobs	0	0	70	1,450	1,450	1,480	1,430	1,530	1,530	1,530
Population Change	0	0	170	3,600	3,610	3,680	3,550	3,580	3,580	3,580
Suboptions Q, Cask, and CM										
Direct Jobs	0	0	45	1,292	1,307	1,347	1,302	1,162	1,162	1,162

Secondary Jobs	0	0	50	1,420	1,430	1,480	1,430	1,460	1,460	1,460
Population Change	0	0	120	3,520	3,560	3,670	3,550	3,410	3,410	3,410

5.3.5 Centralization Alternative

Under this alternative, all current and future SNF would be stored at a centralized location. There are two possible options: the maximum option in which all fuel is stored at Hanford, and the minimum option in which all fuel at Hanford is shipped offsite. The socioeconomic consequences related to implementing the Centralization Alternative suboptions are described in this subsection. The employment and population impacts related to construction and operation of the maximum option are presented in Table 5.3-5. The population and employment impacts related to construction and operation of the minimum option are presented in Table 5.3-6. It was assumed that up to 300 current Hanford workers could be reassigned to operation activities (this number excludes current workers at the Fast Flux Test Facility, as it was assumed that they would be reassigned to activities related to the Hanford Waste Vitrification Plant). Construction activities were assumed to require new workers coming into the area. Estimates of direct jobs were provided by Bergsman (1995). For construction activity, direct jobs were reported as number of jobs in the peak year and total person-years because it was assumed that construction activities would "ramp-up" to the peak year, and then "ramp-down," with the total number of jobs related to construction activity equaling the total person-years required as reported in Bergsman (1995). Although the housing market is currently uncertain and beginning to turn downward, increases in activity levels could strain the housing market and add to school-capacity concerns. However, because construction activities are short-term relative to the total project time frame, impacts from construction activities may be overstated.

5.3.5.1 Centralization - Maximum Option. Under the maximum option,

Hanford SNF would be stabilized and stored under one of the options outlined in the decentralization alternative, with larger storage facilities. A facility would also be built to receive SNF from other sites. Additionally, the ECF would be relocated from the INEL site. The impacts of the ECF to regional population and employment are presented in Appendix D of Volume 1 of this EIS and are not discussed here. Table 5.3-5 presents the employment and population impacts of the options under the maximum centralization option.

5.3.5.1.1 Employment.

All construction activity is assumed to peak in 2000. Construction activity for suboptions W, X, Y, and Z occurs in the years 1997-2000; construction activity for suboptions P and Q occurs in the years 1998-2001; and construction activity for the

Table 5.3-6. Comparison of socioeconomic impacts of spent nuclear fuel Centralization Alternative - minimum case suboptions.

Centralization Alternative	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Suboption P										
Direct Jobs	0	0	0	715	715	715	715	360	360	360
Secondary Jobs	0	0	0	780	780	780	780	460	460	460
Population Change	0	0	0	1,950	1,950	1,950	1,950	1,070	1,070	1,070
Suboption Q										
Direct Jobs	0	0	0	872	872	872	872	786	786	786
Secondary Jobs	0	0	0	960	960	960	960	1,000	1,000	1,000
Population Change	0	0	0	2,380	2,380	2,380	2,380	2,330	2,330	2,330

Suboption D										
Direct Jobs	0	0	619	620	619	619	357	357	357	357
Secondary Jobs	0	0	680	680	680	680	460	460	460	460
Population Change	0	0	1,690	1,690	1,690	1,690	1,060	1,060	1,060	1,060

receiving and canning facility (suboption CM) occurs in the years 1998-2001, with 50% of the construction activity for the modular storage facility occurring during the years 2000-2010 and the other 50% occurring during the years 2010-2035. Increases in employment range from 608 (suboptions X and CM) to 1,401 (suboptions Y, P, and CM) and equate to between 0.7 and 1.7 percentage points over baseline projections of regional employment (see **Table 4.3-1).** All operations activity peaks in 2002, with incremental activity tapering off. Increases in employment range from 164 (suboptions X and CM) to 1,220 (suboptions Q, Small Vault, and CM) persons and equate to between 0.2 and 1.4 percentage points over baseline projections. Beyond 2004, operations activity will taper off as processing activities (suboptions P and Q) will occur only through 2005. Operation of the receiving and canning facility will require 190 workers through 2011, falling to 150 workers through 2035. Suboptions Y and Z each require only 50 workers beyond 2005 for operations activity. Because it is anticipated that up to 300 current workers could be reassigned, no incremental socioeconomic impacts are anticipated after 2005. This is also true with suboptions W and X because each would require only 60 workers for operation activities.

5.3.5.1.2 Population.

For construction-related activities, the population is expected to peak in 2000, with increases in population ranging from 1,620 (suboptions X and CM) to 3,818 (suboptions Y, P, and CM) and equating to between 0.9 and 2.2 percentage points over baseline projections (see Table 4.3-1). All operations activity peaks in 2002, with incremental activity tapering off through 2007. Increases in population range from 450 (suboptions X and CM) to 3,580 (suboptions Q, Small Vault, and CM) persons and equate to between 0.3 and 2.0 percentage points over baseline projections for 2002.

5.3.5.2 Centralization. Minimum Option. Under the minimum option,

Hanford's SNF would be shipped offsite. Some stabilization of fuel would be required prior to shipment of N Reactor and single-pass reactor fuel. Three options were identified for the stabilization: a shear/leach/calcine facility (suboption P); a solvent extraction facility (suboption Q); or a drying and passivation facility (suboption D). Suboptions P and Q are the same processing facilities that were included in the Decentralization Alternative. Table 5.3-6 presents the employment and population impacts of the suboptions under the Centralization minimum option.

5.3.5.2.1 Employment.

All construction activity is assumed to peak **in 1998.** Construction activity for suboptions P and Q occurs in the years 1998-2001. Increases in employment range from 620 (suboption D) to 872 (suboption Q) and equate to between 0.7 and 1.0 percentage points over baseline projections (see Table 4.3-1). All operations activity peaks in 2002, with incremental activity ending after 2006 for suboptions P and Q, and after 2004 for suboption D. Increases in employment range from 357 (suboption D) to 786 (suboption Q) persons and equate to between 0.4 and 0.9 percentage points over baseline projections.

5.3.5.2.2 Population.

For construction-related activities, the population is expected to peak in 1998, with increases in population ranging from 1,690 (suboption D) to 2,380 (suboption Q) and equating to between 1.0 and 1.4 percentage points over baseline projections (see Table 4.3-1). All operations activity peaks in 2002, with incremental activity ending after 2006. Increases in population range from 1,060 (suboption D) to 2,330 (suboption Q) persons and equate to between 0.6 and 1.3 percentage points over baseline projections for 2002.

5.4 Cultural Resources

The potential impacts of SNF management activities on cultural resources were assessed by 1) identifying project activities that could directly or indirectly affect significant resources; 2) identifying the known or expected significant resources in areas of potential impact; and 3) determining whether a project activity would have no effect, no adverse effect, or an adverse effect on significant resources (36 CFR 800.9). Direct impacts are considered to be those associated with ground disturbance or activities that would destroy or]modify an architectural structure. Indirect impacts are considered to be those resulting from improved visitor access, changes in land status, or other actions that limit scientific investigation of the resources.

Possible measures that would be worked out in consultation with the Washington State Historic Preservation Officer (SHPO), Advisory Council for Historic Preservation, and area tribes may include avoidance or data recovery.

5.4.1 No Action Alternative

The No Action Alternative would not involve upgrade or expansion of existing facilities, other than those that may be required to ensure safety and security. Specific actions considered in the No Action Alternative include continued storage at the following facilities:

- 105-KE and 105-KW Basins

y T Plant

- FFTF
- 308 Building
- 324 Building
- 325 Building
- 327 Building
- Low-Level Burial Grounds.

With the exception of FFTF, these are existing Manhattan Project and/or Cold War facilities currently under evaluation for National Register of Historic Places (NRHP) eligibility.

No new facilities would be required; however, the following facility modifications would be considered:

- Upgrade water supply and distribution system to 100-K Area.
- Upgrade seismic adequacy of K Basins.
- Upgrade fire protection systems for the K Basins.
- Safeguards and security upgrades to the K Basins.

Upgrade of the water supply and distribution system has the potential to adversely affect prehistoric archaeological sites in the vicinity of the 100-K Area. Several archaeological sites (45BN115, 45BN152, 45BN423, 45BN434, 45BN464, 45BN424, and H3-10) have been identified in this area (Chatters et al. 1992). These sites are being evaluated for their National Register eligibility. A careful review of the detailed project plans is necessary prior to initiation of this work. If the upgrade results in ground disturbance, as in the replacement and/or addition of new water lines, then these actions could directly affect the archaeological sites. However, proper design of the upgrade system could allow for avoidance of these prehistoric sites. If avoidance is not possible, some sort of data recovery or other measures may be developed in conjunction with affected Native American Tribes and the SHPO. The remaining facility modifications are not likely to affect the historical or architectural value of the Manhattan Project and/or Cold War facilities.

Some indirect effects might result from the continued operation of SNF storage facilities by Hanford workers in the culturally sensitive 100-K Area, if unauthorized artifact collection would contribute to the degradation of nearby archaeological sites. These effects could be mitigated through a worker education program, which would use posters to inform workers of applicable laws, briefing sessions for all persons expected to work along the corridor, and penalties for disturbing an archaeological site. The briefing sessions would stress the importance of cultural resources and specifics of the laws and regulations that exist for site protection.

Direct or indirect impacts are not anticipated to any known traditional cultural resources that are significant to members of the Yakama Indian Nation, the Confederated Tribes of the Umatilla Indian Reservation, or the Wanapum Band. This conclusion is based on the proposed locations of facilities relative to sacred and culturally important areas identified through ethnohistorical research and interviews with elders of bands that formerly used the Hanford Site (Chatters 1989).

5.4.2 Decentralization Alternative

This alternative would involve additional facility upgrades beyond those described for the No Action Alternative, including the construction of new storage facilities and/or a processing facility. Several suboptions have been proposed that would require construction of new facilities. Table 5.4-1 lists the various suboptions and their facility requirements.

Table 5.4-1. Facility requirements of Decentralization suboptions and estimations of area disturbed, [hectares (acres)].

Sub-options	Process option	New pool	New dry vault	New dry casks	New process facility	New land disturbed
W	None	2.4 (6)	2.4 (6)			4.9 (12)
X	None	2.4 (6)		2 (5)		4.5 (11)
Y	P		4.9 (12)		2.4 (6)	7.3 (18)
	Q		2.4 (6)		4.9 (12)	7.3 (18)
	D		4.9 (12)		2.4 (6)	7.3 (18)
Z	P			4.9 (12)	2.4 (6)	7.3 (18)
	Q			2 (5)	4.9 (12)	6.9 (17)
	D			4.9 (12)	2.4 (6)	7.3 (18)

All suboptions would require the temporary use of 105-KE and 105-KW basins for packaging of fuel prior to relocation to a new wet storage facility, or stabilization for dry storage. These are existing Manhattan Project and/or Cold War facilities (currently under evaluation for National Register eligibility). Modifications to these existing facilities are considered to be comparable to those identified in the No Action Alternative.

Actions during the upgrade of the water supply and distribution system for the 100-K Area that disturb ground have the potential to adversely affect prehistoric archaeological sites in the vicinity of the 100-K Area (45BN115, 45BN152, 45BN423, 45BN434, 45BN464, 45BN424, and H3-10). A review of specific upgrade actions is required to determine these effects prior to initiation of these actions. Design of the upgrade system should incorporate avoidance of these prehistoric sites. If avoidance is not possible, some sort of data recovery or other measures may be developed in conjunction with affected Native American Tribes, the SHPO, and the Advisory Council.

An indirect effect of continued operation and maintenance of these facilities is the potential for Hanford workers to conduct unauthorized artifact collection activities. This effect could be mitigated through a worker education program, which would use posters to inform workers of applicable laws, briefing sessions for all persons expected to work along the corridor, and penalties for disturbing an archaeological site. The briefing sessions would stress the importance of cultural resources and specifics of the laws and regulations that exist for site protection.

All of the suboptions would require the construction of new facilities. Wet storage pool and dry storage vault facilities would be cast-in-place concrete structures. The dry cask storage facility would consist of modular storage casks on a concrete pad. The stabilization facilities would be multilevel steel-reinforced, cast-in-place concrete structures. The total land area disturbed by the construction of these facilities is estimated to range from 11 to 18 acres.

All new facilities would be located on a 160-acre site just west of 200-East Area (Figure 4-1). The construction of these facilities is not expected to directly affect any archaeological resources. The proposed project area has been surveyed for cultural resources (HCRC 94-600-001), and no prehistoric or historic archaeological properties were found. Consultation with the State Historic Preservation Office and affected Native American Tribes is still in progress. No indirect effects would be anticipated either because no archaeological sites are known to occur within approximately 4 kilometers of the location proposed for the SNF storage facilities. The SNF facilities would be constructed in an industrialized area and would not alter the feeling or association of the Manhattan Project and/or Cold War facilities located nearby.

Text describing impacts to areas of known traditional or religious significance to specific Native American Tribes for the No Action Alternative in Subsection 5.4.1 also applies to the Decentralization Alternative.

5.4.3 1992/1993 Planning Basis Alternative

This alternative involves continued SNF onsite transportation, receipt, processing, and storage at the Hanford Site. However, the TRIGA fuel currently stored at Hanford would be shipped to INEL. The impacts to cultural resources caused by storage of this fuel at INEL are covered in Volume 1, Appendix B (INEL Spent Nuclear Fuel Management Program). The storage and stabilization facility options for Hanford under this alternative are assumed to be consistent with those of the Decentralization Alternative. Refer to Subsection 5.4.2 for a discussion of the cultural resource impacts.

5.4.4 Regionalization Alternative

All new facilities would be constructed on the 65 hectare (163-acre) site west of 200-East Area (Figure 4.1). Construction of these facilities is not expected to have a direct effect on any significant archaeologic resources. The proposed project area has been surveyed for cultural resources (HCRC 94-600-017), and no prehistoric or historic archaeological properties were found. Two isolated artifacts, one historic and one prehistoric in origin, were recorded during the inventory. Because of their isolated status, neither of the artifacts is considered significant. No indirect effects are anticipated because no known archaeological sites are present within approximately 4 kilometers (2 1/2 miles) of the location proposed for the SNF storage facilities. Because the site for the new SNF facilities is in an industrialized area, construction of these facilities would not alter the feeling or association of the Manhattan Project and/or Cold War facilities located nearby.

Although no cultural resource impacts are expected, the potential for discovery during construction is proportional to the amount of land that would be disturbed. For the various options of the Regionalization Alternative, those areas would amount to the following amounts of land:

A) From about 2 to 7 hectares (6 to 18 acres) when all SNF, except defense production SNF, would be sent to INEL

B1) From about 14 to 17 hectares (36 to 43 acres) when all SNF west of the Mississippi River, with the exception of Naval SNF, would be sent to Hanford

B2) From about 24 to 27 hectares (61 to 68 acres) when all SNF west of the Mississippi River and Naval SNF would be sent to Hanford

C) About 2 to 5 hectares (6 to 12 acres) when all Hanford SNF would be sent to INEL or NTS.

In any event, the maximum option would require a processing facility (equivalent to Decentralization process options P, Q, or D) with a specialty fuel processing area; an inspection and packaging facility; an SNF storage complex (similar to, but larger than that for the Decentralization options W, X, Y, or Z); and a new Expended Core Facility. The existing 105-KE and 105-KW basins would be used to package fuel for wet transport to the processing facility. These are existing Manhattan Project and/or Cold War facilities that are currently under evaluation for National Register eligibility. Modifications to these facilities are considered to be similar to those depicted for the No Action and Decentralization alternatives (refer to Subsections 5.4.1 and 5.4.2). Ground-disturbing upgrades to the 100-K Area water supply and distribution system are considered to have potentially adverse effects on prehistoric archaeological sites 45BN115, 45BN152, 45BN423, 45BN434, 45BN424, H3-10, and/or 45BN464 located in this vicinity. A review of the specific upgrade plans is required to determine the effects before beginning these activities. Design of the upgraded water supply system should incorporate avoidance of the prehistoric sites. If avoidance is not possible, then some data recovery or other measures would be developed in conjunction with the affected Native American Tribes, the SHPO, and the Advisory Council. Text describing potential unauthorized artifact collection and possible mitigation measures for the Decentralization Alternative in Subsection 5.4.2 also applies to the Regionalization Alternative.

Text describing impacts to areas of known traditional or religious significance to specific Native American Tribes for the No Action Alternative in Subsection 5.4.1 also applies to the Regionalization Alternative.

5.4.5 Centralization Alternative

This alternative consists of two scenarios: shipment of all SNF off of the Hanford Site (minimum option), and storage of all SNF at the Hanford Site (maximum option). For the minimum option, a new fuel stabilization and packaging (canning) facility would be constructed.

The maximum option would require a processing facility (equivalent to Decentralization process options P, Q, or D) with a specialty fuel processing area; an inspection and packaging facility; an SNF storage complex (similar to the decentralization options W, X, Y, or Z); and a new Expended Core Facility. The existing 105-KE and 105-KW Basins would be used to package defense production fuel for wet transport to the processing facility. These are existing Manhattan Project and/or Cold War facilities that are currently under evaluation for National Register eligibility. Modifications to these facilities are considered to be similar to those depicted for the No Action and Decentralization Alternatives (refer to Subsections 5.4.1 and 5.4.2). Ground-disturbing upgrades to the 100-K Area water supply and distribution system are considered to have potentially adverse effects on prehistoric archaeological sites 45BN115, 45BN152, 45BN423, 45BN434, 45BN424, H3-10, and/or 45BN464 located in this vicinity. A review of the specific upgrade plans is required to determine the effects before beginning these activities. Design of the upgraded water supply system should incorporate avoidance of the prehistoric sites. If avoidance is not possible, then some data recovery or other measures would be developed in conjunction with the affected Native American Tribes, the SHPO, and the Advisory Council. Text describing potential unauthorized artifact collection and possible mitigation measures for the Decentralization Alternative in Subsection 5.4.2 also applies to the Centralization Alternative.

All new facilities would be constructed on the 160-acre site west of 200-East Area (Figure 4.1). The construction of these facilities is not expected to have a direct effect on any archaeologic resources. The proposed project area has been surveyed for cultural resources (HCRC 94-600-001), and no prehistoric or historic archaeological properties were found. No indirect effects are anticipated because no known archaeological sites are present within approximately 4 kilometers of the location proposed for the SNF storage facilities. The site for the new SNF facilities is in an industrialized area, thus construction of these facilities would not alter the feeling or association of the Manhattan Project and/or Cold War facilities located nearby.

Text describing impacts to areas of known traditional or religious significance to specific Native American Tribes for the No Action Alternative in Subsection 5.4.1 also applies to the Centralization Alternative.

5.5 Aesthetic and Scenic Resources

Implications of implementing the alternatives for interim storage of SNF on aesthetic and scenic resources at the Hanford Site are discussed in the following subsections.

5.5.1 No Action Alternative

Impacts from this alternative would have no effect on the aesthetic and scenic resources.

5.5.2 Decentralization Alternative

This alternative would require the construction of an SNF facility at Hanford, where most SNF from the Hanford Site would be stored.

Changes caused by construction and operation of an SNF facility would be consistent with the existing overall visual environment of the Hanford Site. Topographic features obstruct the SNF site from view from populated areas. The site could be seen from the farmland bluffs that overlook the Columbia River on the east. However, these lands are on private property not readily accessible to the public. Landowners would likely grant access permission only during the hunting season, if at all. No impacts requiring mitigation would occur to the aesthetics or to the visual environment as a result of construction or operation of an SNF facility at the Hanford Site.

5.5.3 1992/1993 Planning Basis Alternative

Activities in this alternative are sufficiently similar to those of the Decentralization Alternative that they are not repeated here.

5.5.4 Regionalization Alternative

This alternative (see Section 5.1.4 for details) would require the construction of a variety of SNF facilities depending on the option chosen. The facilities would range from a packaging/stabilization facility if all fuel were to be removed from Hanford (option C) to storage facilities for all SNF west of the Mississippi River (option B2). However, changes caused by construction and operation of these facilities would be consistent with the existing overall visual environment of the Hanford Site. Topographic features obstruct the SNF site from view from populated areas. The site could be seen from the farmland bluffs to the east of the site that overlook the Columbia River. However, these lands are on private property that is not readily accessible to the public. Landowners would likely grant access permission only during the hunting season, if at all.

No impacts requiring mitigation would occur to the aesthetics or to the visual environment as a result of construction or operation of an SNF facility at the Hanford Site.

5.5.5 Centralization Alternative

If Hanford is selected as the site for centralization of SNF, then the SNF facility and its support facilities would be constructed here.

Changes caused by construction and operation of an SNF facility would be substantially larger in the Centralization Maximum Alternative. However, they would be consistent with the existing overall visual environment of the Hanford Site. Topographic features obstruct the SNF site from view from populated areas. The site could be seen from the farmland bluffs that overlook the Columbia River on the east. However, these lands are on private property not readily accessible to the public. Landowners would likely grant access permission only during the hunting season, if at all.

No impacts requiring mitigation would occur to the aesthetics or to the visual environment as a result of construction or operation of an SNF facility at the Hanford Site. If Hanford is not selected as the site for centralization of SNF, only an SNF packaging/ processing facility for shipment of fuel would be constructed and there would be even less potential for impact to the aesthetic and scenic resources.

5.6 Geologic Resources

No postulated impacts to the geologic resources of the Hanford Site have been identified under any of the alternatives. Thus, geologic resources would remain as described under Section 4.6.

5.7 Air Quality and Related Consequences

The consequences of the five alternatives on ambient air quality at the Hanford Site are presented in this section. In the case of radiological emissions, the consequences are compared among the alternatives and to current Hanford Site operations. For nonradiological emissions, projected ambient concentration at key receptor locations are compared with current concentrations at the Hanford Site. Development of the specific analysis for each alternative is discussed in subsequent subsections.

The consequences of radiological emissions were evaluated using the GENII computer code package (Napier et al. 1988). The radiological consequences of airborne emissions during normal operation have been estimated for the SNF storage alternatives considered in this document. Three separate analyses were performed for each facility included in a particular alternative using the GENII computer code. The receptors evaluated in these cases were at the location of maximum exposure representing a potential onsite worker outside of the SNF facility, the maximally exposed offsite resident, and the collective population within 80 kilometers. Standard parameters for radiological dose calculations at the Hanford Site were used for these estimates (Schreckhise et al. 1993). The maximum impact of each alternative on offsite receptors and workers was obtained by summing the consequences associated with the individual facilities, although these receptors may be physically at very different locations. The health consequences in terms of cancer fatalities were calculated using recommendations of the International Commission on Radiological Protection in its Publication 60 (ICRP 1991) - 4E-04 fatal cancers/rem for workers and 5E-04 fatal cancers/rem for the general population. Risk conversion factors were applied to both individual and collective doses, although they are based on population averages for individuals with varying degrees of sensitivity. The individual risk estimates therefore represent the risk to a hypothetical individual, which would be somewhat lower than the risk to more sensitive members of the population.

None of the alternatives would result in a dose to the maximally exposed offsite resident that exceeds 1 percent of the current EPA standard of 10 millirem/year. The consequences of the No Action Alternative are caused by emissions from existing facilities where spent fuel is stored. These facilities contribute a relatively small fraction of the total dose from airborne emissions at all Hanford Site operations (less than half and likely much less). The No Action Alternative represents the baseline for SNF operations at Hanford. The consequences of the Decentralization, Regionalization, and Centralization Alternatives vary depending on which storage and processing options are considered. Options including processing of defense reactor fuel result in the highest doses, which are at most an order of magnitude greater than those in the No Action Alternative. The consequences of options involving only containerization of defense reactor fuel followed by wet storage, and dry storage of all other fuel, in a new facility are approximately an order of magnitude lower than those in the No Action Alternative.

The potential nonradiological air quality pollutants of concern for this assessment include all pollutants for which there exist federal, state, or local standards. This includes both the standard set of criteria pollutants (e.g., nitrogen dioxide, oxides of sulfur, respirable particles) and toxic pollutants.

For criteria pollutants, concentration levels are regulated by the provisions of the Clean Air Act; Washington State standards for these criteria pollutants are at least as stringent as the federal standards. In the State of Washington, the Department of Ecology has the responsibility for promulgating and enforcing air quality standards for the protection of public health. The regulation that governs the control of toxic air pollutants (WAC 1990a,b) requires the owners of new or modified air emission sources to apply for approval before construction. Owners of sources emitting toxic air pollutants must demonstrate that they will employ the best available control technology for emissions control with reasonable environmental, energy, and economic impacts.

Construction of new facilities can also negatively impact air quality through the emission of fugitive dusts. To model this aspect, the EPA's Fugitive Dust Model (FDM) was selected. This model is especially designed to compute the air quality impacts from fugitive dust emissions, such as those associated with facility construction sites (Winges 1992). The FDM uses steady-state Gaussian plume algorithms and a gradient-transfer deposition algorithm to compute air quality impacts. Emissions for each source must be apportioned into a series of particle-size classes; each of which is assigned a representative deposition velocity. The model can operate using either joint frequency distributions or hourly meteorological data to represent atmospheric conditions. The model can handle up to 200 sources and 500 receptors per model run. The user may define a variety of point, line, area, and volume sources.

The Industrial Source Complex (ISC2) models were selected to estimate routine nonradiological air quality impacts. There are two ISC2 models: the ISC2 short-term model (ISCST2) and the ISC2 long-term model (ISCLT2). The two ISC2 models use steady-state Gaussian plume algorithms to estimate pollutant concentrations from a wide variety of sources associated with industrial complexes (EPA 1992). The models are appropriate for flat or rolling terrain, modeling domains with a radius of less than 50 kilometers, and urban or rural environments. The ISC2 models have been approved by the EPA for specific regulatory applications and are designed for use on personal computers. Input requirements for the ISC2 model include a variety of information that defines the source configuration and pollutant emission parameters. The user may define a variety of point, line, area, and volume sources. The ISCST2 model uses hourly meteorological data and joint frequency distribution data to compute straightline plume transport. Plume rise, stack-tip downwash, and building wake can be computed. The ISC2 models compute a variety of short- and long-term averaged products at user-specified receptor locations and receptor rings. The ISC2 models also treat deposition processes and allow the exponential decay of pollutants.

5.7.1 No Action Alternative

Facilities included in the No Action Alternative consist of those where SNF is currently stored at the Hanford Site. Minimal repackaging, stabilization, and relocation of fuel would be undertaken to ensure continued safe storage prior to ultimate disposition. The majority of spent fuel at Hanford is located at the 100-K Area wet storage basins. In addition, smaller quantities of fuel are stored at other onsite facilities. These include T Plant and a low-level waste burial ground in the 200-West Area; the Fast Flux Test Facility in the 400 Area; and the 308, 324, 325, and 327 buildings in the 300 Area. Releases for the No Action Alternative are based on operations for these facilities during 1992 (Bergsman 1995). These emissions were assumed to represent operations at existing SNF storage facilities over the EIS evaluation period, although they are subject to change with individual facility missions and operating status. It should also be noted that some existing facilities support a variety of other programs in energy research and waste management in addition to laboratory and hot cell examination of fuel materials. The historical releases from these multi-purpose facilities may reflect other activities in addition to spent fuel storage. The past operating emissions, therefore, represent an upper bound estimate for the fuel storage activities. The No Action Alternative also represents the baseline of maximum expected impacts for future spent fuel storage activities.

5.7.1.1 Radiological. Radiological air emissions for normal operation

of existing fuel storage facilities in the No Action Alternative are listed in Tables 5.7-1 through 5.7-3 (DOE/RL 1993). The sealed fuel canisters temporarily stored at the 200-West Area burial ground are assumed to release negligible quantities of radionuclides in this analysis, although actual emissions from the stored fuel have not been quantified.

The consequences of air emissions from existing facilities utilized in the No Action Alternative are summarized in Table 5.7-4 and include a maximum annual dose of 1E-5 rem to a potential onsite worker with a 5E-9 probability of fatal cancer. The maximum dose to an offsite resident is estimated as 3E-6 rem/year, and the corresponding probability of fatal cancer is 1E-9. The dose estimate for an onsite worker or an offsite individual represents the sum of doses to separate maximally exposed individuals for each of the facilities included in the alternative. Because these facilities are in different areas of the Hanford Site, the respective maximally exposed workers and offsite residents are at different locations. The actual dose to a single worker or

Table 5.7-1. Annual atmospheric releases for normal operation - wet storage basins at 100-KE Area and 100-KW Area.

Radionuclide	100-KE Area Release (Ci/yr)	100-KW Area Release (Ci/yr)
Cobalt-60	1.3E-06	1.4E-06
Strontium-90	1.6E-04	9.9E-07
Ruthenium-106	1.3E-05	6.2E-06
Antimony-125	1.1E-05	NA[a]
Cesium-137	2.3E-04	2.7E-05
Europium-154	NA	4.9E-06
Plutonium-238	1.3E-06	3.0E-08
Plutonium-241	3.9E-05	NA
Americium-241	5.1E-06	NA
Plutonium-239	8.5E-06	1.8E-07
Tritium	(b)	(b)

a. NA indicates not available.

b. Although tritium emissions are not routinely monitored at these facilities, the releases from both basins were recently estimated as 1-2 Ci/year. These emissions could account for up to 25% of the total dose from these facilities to the maximally exposed offsite resident. However, the contribution from the 100 area tritium emissions would not change the estimated dose from all Hanford emissions to the site's maximally exposed offsite resident.

Table 5.7-2. Annual atmospheric releases for normal operation - fuel storage at 300 Area 308, 324, 325, and 327 buildings.

Radionuclide	308 Building Release (Ci/yr)	324 Building Release (Ci/yr)	325 Building Release (Ci/yr)	327 Building Release (Ci/yr)

Tritium	NAa	9.6E+00	2.5E+01	NA
Total betab	1.1E-07	6.4E-07	2.4E-06	9.3E-07
Total alphac	3.0E-08	3.9E-07	8.5E-07	1.1E-07

a. NA indicates not available.
b. Total beta emissions were assumed to be strontium-90 for modeling purposes.
c. Total alpha emissions were assumed to be plutonium-239 for modeling purposes.

Table 5.7-3. Annual atmospheric releases for normal operation - fuel storage at 200 West Area T Plant and 400 Area FFTF.

Radionuclide	200-West Area T Plant Release (Ci/yr)	400 Area FFTF Release (Ci/yr)
Argon-41	NAa	8.5E+00b
Total beta/strontium-90	1.2E-05	6.7E-06c
Cesium-137	1.3E-05	NA
Americium-241	2.0E-06	NA
Total alpha/plutonium-239	2.2E-05	1.1E-06d

a. NA indicates not available.
b. Releases of Ar-41 occurred during reactor operation in 1992. The reactor was subsequently shut down, and releases of short-lived activation products are not anticipated from future fuel storage activities.
c. Total beta emissions were assumed to be strontium-90 for modeling purposes.
d. Total alpha emissions were assumed to be plutonium-239 for modeling purposes.

offsite resident from all facilities combined would therefore be less than the sum of the individual facility receptor doses reported in Table 5.7-4. The peak collective dose to the population within 80 kilometers (50 miles) is 3E-2 person-rem per year, which is predicted to result in less than one fatal cancer (6 x 10-4) over 40 years of storage.

5.7.1.2 Nonradiological Consequences. The No Action Alternative

involves no new construction so there would not be an increase in particulate emissions. The facilities currently used in storing the SNF do not have any nonradiological releases, so there would be no increase in concentrations of these pollutants.

5.7.2 Decentralization Alternative

The Decentralization Alternative permits construction of new facilities where these represent an improvement over current storage practices. Relocation of fuel could be undertaken as part of this alternative to meet programmatic needs; however, no fuel would be shipped to, or received from, offsite locations. It is assumed for purposes of this analysis that new facilities would be constructed under this alternative, and that they would be located in a dedicated SNF management complex adjacent to the 200-East Area.

Table 5.7-4. Radiological consequences of airborne emissions during normal operation in the No-Action Alternative for spent nuclear fuel storage at Hanford.

		Onsite worker		Offsite resident		80 kilometer population	
Area	Facility	Peak annual dose (EDE) (rem/yr)	Probability of fatal cancer	Peak annual dose (EDE) (rem/yr)	Probability of fatal cancer	Peak annual dose (EDE) (person-rem/yr)	Number of fatal cancers
100 KE	Wet Basin	9.3E-06		2.0E-07		5.7E-03	
100 KW	Wet Basin	1.2E-07		3.3E-09		9.1E-05	
300	308 Bldg	3.3E-09		2.1E-09		1.4E-05	

300	324 Bldg	1.4E-08		2.9E-07		3.0E-03	
300	325 Bldg	1.2E-07		1.9E-06		1.1E-02	
300	327 Bldg	1.7E-09		2.4E-09		2.6E-05	
200 W	Burial Ground	0.0E+00		0.0E+00		0.0E+00	
200 W	T Plant	1.3E-07		3.3E-08		2.4E-03	
400	Fast Flux Test Facility	1.9E-06		1.9E-07		4.1E-03	
Total from All Facilities		1.2E-05	4.6E-09	2.6E-06	1.3E-09	2.7E-02	1.3E-05

The Decentralization Alternative at Hanford includes two basic options, each with several suboptions depending on the types of storage and processing facilities included. The first major option includes a combination of wet storage of defense production fuel and dry storage of all other fuel in either a small vault facility (suboption W) or in casks (suboption X). The second major option provides for dry storage of all fuel, which would require processing of defense fuel prior to dry storage. If a shear/leach/calcine process is used (suboption P), the calcine product and all other fuel would be consolidated in a single large vault facility (suboption Y) or in casks (suboption Z). If a solvent extraction process is chosen for the defense fuel (suboption Q), the oxide products could be stored in either new or existing facilities that would have lower space and shielding requirements than for the calcine product. A high-level liquid waste stream would also be produced and transferred to underground storage tanks. All fuel other than the processed defense fuel would be stored in a small vault facility or in casks as in suboptions W and X.

5.7.2.1 Radiological. Estimated radiological air emissions for normal operations of new facilities in the Decentralization Alternative are listed in Tables 5.7-5 through 5.7-7. The dry storage facilities are assumed to have no radiological emissions under normal operating conditions because all fuel is contained in sealed decontaminated canisters and storage casks. Therefore, there is no mechanism for routine release of radionuclides from dry storage facilities over the time period covered in this document.

The consequences of air emissions from individual facilities in the Decentralization Alternative are summarized in Table 5.7-8 and include a maximum annual dose of 2E-9 rem to a

Table 5.7-5. Estimated annual atmospheric releases for normal operation - new wet storage at 200-East Area.

Radionuclide	Release (Ci/yr)
Cobalt-60	1.4E-05
Strontium-90	1.1E-06
Ruthenium-106	6.2E-06
Cesium-137	2.3E-05
Europium-154	4.9E-06
Plutonium-238	1.1E-08
Plutonium-239	6.7E-08

Table 5.7-6. Estimated annual atmospheric releases for normal operation - shear/leach/calcine fuel process at 200-East Area.

Radionuclide	Release (Ci/yr)
Tritium	7.0E+02
Carbon-14	6.5E+00
Krypton-85	2.7E+05
Strontium-90	4.8E-07
Ruthenium-106	4.3E-09
Antimony-125	1.0E-08
Tellurium-125M	2.5E-09
Iodine-129	5.0E-03
Cesium-134	1.0E-08
Cesium-137	6.0E-07
Cerium-144	2.3E-09
Promethium-147	1.6E-07
Samarium-151	7.4E-09
Europium-154	7.2E-09
Americium-242	2.4E-12
Curium-242	6.1E-12

Plutonium-238	3.2E-09
Plutonium-241	3.8E-07
Americium-241	7.8E-09
Plutonium-239/240	0.00000002

potential onsite worker (8E-13) probability of fatal cancer) for the option including a combination of wet and dry spent fuel storage facilities. The dose to an offsite resident at the highest exposure location is estimated as 6E-10 rem/year, and the corresponding probability of fatal cancer is 3E-13. The peak collective dose to the population within 80 kilometers is 2E-5 person-rem per year, which is predicted to result in less than one (4 x 10-7) fatal cancer over 40 years of storage.

Table 5.7-7. Estimated annual atmospheric releases for normal operation - spent nuclear fuel solvent extraction fuel process at 200-East Area.

Radionuclide	Release (Ci/yr)
Tritium	7.0E+02
Carbon-14	6.5E+00
Krypton-85	2.7E+05
Strontium-90	2.4E-02
Ruthenium-106	5.1E-04
Antimony-125	4.6E-04
Tellurium-125M	2.4E-04
Iodine-129	1.9E-02
Cesium-134	5.1E-04
Cesium-137	3.0E-02
Cesium-144	1.2E-04
Promethium-147	8.1E-03
Samarium-151	7.4E-09
Europium-154	4.2E-04
Europium-155	1.7E-04
Americium-242	2.4E-12
Curium-242	6.1E-12
Plutonium-238	1.6E-03
Plutonium-241	1.9E-02
Americium-241	4.4E-03
Plutonium-239/240	0.008

Table 5.7-8. Radiological consequences of airborne emissions during normal operation in the Decentralization Alternative for spent nuclear fuel storage at Hanford.

		Onsite worker		Offsite resident		80 km population	
Area	Facility	Peak annual dose (EDE) (rem/yr)	Probability of fatal cancer	Peak annual dose (EDE) (rem/yr)	Probability of fatal cancer	Peak annual dose (EDE) (person-rem/yr)	Number of fatal cancers
Combination Wet + Dry Storage Option							
200 E	New Wet Storage	2.0E-09	8.0E-13	5.7E-10	2.8E-13	2.3E-05	1.2E-08
200 E	New Dry Storage	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Dry Storage Only Option with Defense Fuel Processing							
200 E	New Dry Storage	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
200 E	New Fuel Calcine	4.1E-06	1.7E-09	7.0E-06	3.5E-09	3.4E-01	1.7E-04
200E	New Solvent Extraction	2.7E-05	1.1E-08	2.1E-05	1.1E-08	1.3E+00	6.3E-04

For the all dry storage option, processing defense fuel is required in the Decentralization Alternative (suboptions P and Q), and additional emissions would result from these activities if they were conducted. The dose to the onsite worker from air emissions would be 4E-6 rem per year for a shear/leach/calcine process or 3E-5 rem per year for a solvent extraction process (2E-9 or 1E-8 probability of fatal cancer, respectively) in addition to those from the dry storage facility. The corresponding consequences for the offsite resident would be 7E-6 rem per year (4E-9 probability of fatal cancer) for the shear/leach/calcine facility and 2E-5 rem per year (1E-8 probability of fatal cancer) for the solvent extraction facility. The collective dose to the offsite population from the respective fuel processing facilities is estimated at 0.3 to 1 person-rem per year, resulting in less than one expected fatal cancer (<0.02) over 40 years of storage.

5.7.2.2 Nonradiological Consequences. Fugitive dust emissions from new

construction activities, toxic chemical emissions, and nitrogen oxide emissions from fuel processing would contribute to the non-radiological emissions in the Decentralization Alternative.

5.7.2.2.1 Fugitive Dust.

Three different construction options are under consideration in this alternative: 1) construction of wet and dry storage facilities, 2) construction of dry storage and the shear/leach/calcine facility, and 3) construction of a dry storage and a solvent extraction facility. In options 1 and 2, approximately 12 acres would be disturbed for the construction of the storage facilities; in option 3, 6 acres would be disturbed for the dry storage facility. An additional 6 acres would be disturbed for the shear/leach/calcine facility or 12 acres for the solvent extraction facility. In total up to 12 acres would be disturbed in the first option and 18 acres in the second and third options (Bergsman 1995).

Details of the construction process are not available for the alternatives, but a standard default value of 1.2 tons/acre/month of particles can be assumed to be generated during new construction (EPA 1977). Most of the particles produced by construction activities are large and settle a short distance from the source (Seinfeld 1986). A conservative estimate is that approximately 30 percent of the mass released would be particles small enough to be transported away from the construction site (EPA 1988).

Experience with construction activities at Hanford indicates that fugitive dust concentrations at the nearest point of public access and at the site boundaries would be less than Washington State PM10 limits for both annual and 24-hour averages. Standard control techniques (such as applying water to the disturbed ground) could be used to limit the PM10 emissions at the construction site and resulting airborne concentrations. Although extensive construction activities have the potential to contribute to short-term airborne particulate concentrations if they coincide with high wind events, such effects would generally be obvious only in the immediate area and could be mitigated by dust control measures over both the short and long term. In any case, such activities would be temporary and would not adversely affect regional air quality on a continuing basis. Construction activities would also result in increased emissions of pollutants from diesel- and gasoline-powered construction equipment. However, the increase in ambient levels of pollutants would be minimal because of the relatively low levels of emission and large distances to the nearest points of public access and the site boundary.

5.7.2.2.2 Nitrogen Oxides.

Nitrogen oxide emissions during facility operation are approximately the same for both the shear/leach/calcine facility and the solvent extraction facility. It is assumed that all nitrogen oxide emissions are in the form of nitrogen dioxide. Annual concentrations at the nearest point of public access, 7.5 kilometers (6.4 miles) southwest of the release site, are estimated to be 0.1 micrograms per cubic meter. This concentration is 0.1 percent of the allowed Washington State standard and 0.4 percent of the Prevention of Significant Deterioration (PSD) standard.

Nitrogen oxide concentrations were also calculated for onsite locations. The maximum annual concentration estimated by the model is 1.2 micrograms per cubic meter, which occurs 500 meters (0.3 miles) south of the processing facility. The maximum ground level concentration is some distance from the processing facility because the emissions are from an elevated stack rather than at ground level. For example, at a distance of 100 meters (0.06 miles) from the base of the facility, the greatest estimated nitrogen oxide annual concentration is only 1.8 x 10-5 micrograms per cubic meter.

5.7.2.2.3 Toxic Chemical Emissions.

Information about routine toxic chemical emissions from either the shear/leach/calcine facility or the solvent extraction facility is unavailable. However control techniques would be used to ensure that concentrations of toxics in the atmosphere comply with the DOE abatement policy and local permitting requirements.

5.7.3 1992/1993 Planning Basis Alternative

The 1992/1993 Planning Basis Alternative is assumed to be similar to the Decentralization Alternative discussed in the previous section, including construction of wet or dry storage facilities adjacent to the 200-East Area and process facilities for defense production fuel if it is to be stored dry. The only change to the Hanford Site fuel inventory would involve shipment of a relatively small quantity of TRIGA fuel to an offsite location. This would not substantially alter the scope of planned spent fuel storage activities, and the 1992/1993 Planning Basis Alternative assumes emissions for new facilities are the same as those in the Decentralization Alternative.

5.7.3.1 Radiological Consequences. The consequences for this

alternative are assumed to be the same as those for the Decentralization Alternative. Refer to Table 5.7-8 for the list of facilities included in this option and their consequences.

5.7.3.2 Nonradiological Consequences. The consequences for this

alternative are considered to be the same as those for the Decentralization Alternative.

5.7.4 Regionalization Alternative

The Regionalization Alternative at Hanford includes three options, depending on the quantity of SNF shipped to, or from, the site. Option A provides for regional storage of SNF by type, and would entail shipping all fuel at Hanford except defense production fuel to another location. In this case, defense fuel would either be stored wet at a new pool facility, or it would be processed for dry storage using suboptions similar to those described in the Decentralization Alternative.

An additional option in the Regionalization Alternative describes importing SNF to Hanford from other sites based on their geographic distribution. In the first option, designated Option B1, all fuel at locations west of the Mississippi River except Naval SNF would be stored at Hanford. In the second option, designated Option B2, all SNF at locations west of the Mississippi River and Naval SNF would be stored at Hanford. All imported fuel would ultimately be placed into a new dry storage facility, the size of which would be determined by the quantity of imported fuel to be stored. In addition, a receiving and canning facility would be built to repackage any fuel as needed, and to provide temporary wet storage for fuels that could not be immediately placed into dry storage. This option would also include a technology development facility for fuel characterization and research related to SNF management. SNF currently at Hanford would be stored according to the options described in the Decentralization Alternative. Option B2 would include a separate facility to examine and characterize Naval SNF, as described in Appendix D to Volume 1 of this EIS.

The third Regionalization option (designated Option C) would relocate all SNF at the Hanford Site to another western U.S. location. The only new facility that would be required for this option is a processing and packaging facility to stabilize and repackage defense fuel and to place other fuel into canisters as needed for shipping offsite. Prior to preparation for offsite shipment, SNF would continue to be managed at existing facilities, as for the No Action Alternative. All new facilities considered in the Regionalization Alternative options would be constructed in a dedicated SNF management complex adjacent to the 200-East Area, as for the Decentralization Alternative.

5.7.4.1 Radiological Consequences. Emissions from new facilities in

Regionalization Alternative A would be the same as those described for the Decentralization Alternative in Table 5.7-8. Although this option does not include the dry storage capacity for fuel other than defense production fuel, dry storage facilities add nothing to the normal operating emissions; therefore, the emissions and consequences from this alternative would be quantitatively the same as those previously described for the Decentralization Alternative.

Emissions from the new facilities in the Regionalization Alternative B and C options are expected to be bounded by those in the Centralization maximum and minimum options, respectively, as described in Section 5.7.5.

5.7.4.2 Nonradiological Consequences. Because of the similarity of

operations, consequences for the Regionalization Alternative are considered to be the same as those for the Decentralization Alternative.

5.7.5 Centralization Alternative

The Centralization Alternative at Hanford includes two options: a maximum option in which all SNF for which DOE is responsible would be stored at Hanford, and a minimum option in which all SNF currently at Hanford would be shipped to another site. The maximum option is similar to that described in the Regionalization Option B2, except that the size of the receiving and canning and dry storage facilities would be increased as necessary to accommodate the larger quantity of imported fuel. The minimum option is identical to that described for the Regionalization Alternative, Option C. All new facilities considered in the Centralization Alternative options would be constructed in a dedicated SNF management complex adjacent to the 200-East Area.

5.7.5.1 Radiological. For the Centralization maximum option at

Hanford, emissions from the wet storage and processing facilities would be identical to those described in the Decentralization Alternative (refer to Tables 5.7-5 through 5.7-7). Minimal emissions from the large dry storage facility are assumed in this case (see Table 5.7-9) because some of the imported fuel could be stored without canning, and the assumption of zero emissions could not be justified as in the Decentralization Alternative. The consequences of emissions from a relocated Expended Core Facility (ECF) are described in Appendix D to Volume 1 of this EIS and are not included here. It should be noted that the assumptions used in Appendix D calculations for the ECF at Hanford may differ from those used to estimate the consequences of emissions from other Hanford facilities.

The consequences of air emissions from individual facilities in the Centralization Alternative maximum option are summarized in Table 5.7-10 and include a maximum annual dose of 9E-9 rem to a potential worker (4E-12 probability of fatal cancer) for a combination of wet and dry spent fuel storage facilities. The dose to an offsite resident at the highest exposure location is estimated as 2E-9 rem/year, and the corresponding probability of fatal cancer is 8E-13. The peak collective dose to the population within 80 kilometers is 7E-5 person-rem per year, which is predicted to result in less than one (4 x 10-8) fatal cancer.

Table 5.7-9. Estimated annual atmospheric releases for normal operation - new dry storage at 200-East Area (maximum option).

Radionuclide	200-East Area Release (Ci/yr)
Cobalt-60	2.8E-08
Strontium-90	9.1E-07
Yttrium-90	9.1E-07
Cesium-137	1.2E-07
Plutonium-239	2.8E-07

Table 5.7-10. Radiological consequences of airborne emissions during normal operation in the

Centralization Alternative for spent nuclear fuel storage at Hanford.

Area	Facility	Onsite worker		Offsite resident		80 km population	
		Peak annual dose (EDE) (rem/yr)	Probability of fatal cancer	Peak annual dose (EDE) (rem/yr)	Probability of fatal cancer	Peak Annual Dose (EDE) (Person-rem/yr)	Number of Fatal Cancers
Combination Wet + Dry Storage Option							
200 E	New Wet Storage	2.0E-09	8.0E-13	5.7E-10	2.9E-13	2.3E-05	1.2E-08
200 E	New Dry Storage	7.0E-09	3.0E-12	1.0E-09	5.0E-13	4.8E-05	2.4E-08
Dry Storage Only Option with Defense Fuel Processing							
200 E	New Dry Storage	7.0E-09	3.0E-12	1.0E-09	5.0E-13	4.8E-05	2.4E-08
200 E	New Fuel Calcine	4.1E-06	1.7E-09	7.0E-06	3.5E-09	3.4E-01	1.7E-04
200E	New Solvent Extraction	2.7E-05	1.1E-08	2.1E-05	1.1E-08	1.3E+00	6.3E-04
Relocation of Expended Core Facility[a]							

[a] Data for the expended core facility (ECF) are presented in Appendix D to Volume 1 of this EIS. Assumptions used in Appendix D calculations for the ECF at Hanford may differ from those used to estimate the doses consequences of emission from other Hanford facilities.

Processing of defense fuel is required prior to dry storage in the maximum option, and additional air emissions would result from those activities if defense fuel is stored dry rather than wet. The dose to the worker would increase by 4E-6 rem/year for a shear/ leach/ calcine process or 3E-5 rem/year for a solvent extraction process (2E-9 or 1E-8 probability of fatal cancer, respectively). The corresponding added consequences for the offsite resident would be 7E-6 rem/year (4E-9 probability of fatal cancer) for the shear/leach/calcine facility and 2E-5 rem/year (1E-8 probability of fatal cancer) for the solvent extraction facility. The collective dose to the offsite population from the respective fuel processing facilities is estimated at 0.3 to 1 person-rem per year, resulting in less than one (5 x 10-4) fatal cancer.

In the Centralization Alternative minimum option, the consequences of existing facilities utilized for interim fuel storage prior to shipment offsite are the same as in the No Action Alternative. Consequences for defense fuel processing prior to shipment are described under the centralization maximum alternative and are equivalent to those from the shear/leach/calcine facility. Refer to Tables 5.7-4 and 5.7-10 for the consequences of facilities included in this option.

5.7.5.2 Nonradiological. Because of the similarity of operations

leading to nonradiological impacts on air quality, consequences for the Centralization Alternative are considered to be the same as those for the Decentralization Alternative with the addition of emissions from the naval fuels Expended Core Facility. Analysis of nonradiological releases from the Expended Core Facility can be found in Volume 1, Appendix D.

5.8 Water Quality and Related Consequences

This section evaluates the potential impacts to groundwater and surface water resources from the construction and operation of SNF storage and associated support facilities at the Hanford Site. Potential impacts to groundwater and surface water, water use, and water quality from the potential release of contaminants into, and migration through, hydrologic water-based environments are evaluated. The potential significance of these impacts is evaluated with respect to environmental contaminant levels from potential releases of contaminants into the environment and the health impacts of these contaminant levels. Contaminant waste streams include radionuclide and chemical carcinogens and noncarcinogenic chemicals.

The Multimedia Environmental Pollutant Assessment System (MEPAS), a computer model, was utilized to simulate the release, migration, fate, exposure, and risk to surrounding receptors of wastes that are discharged into the environment from the operation of SNF facilities. The MEPAS model is a fully integrated, physics-based, PC-platform, intermedia transport- and risk computation code that is used to assess health impacts from actual and potential releases of both hazardous chemicals and radioactive materials. The MEPAS model is designed for site-specific assessments using readily available information. It follows EPA risk-assessment guidance in evaluating 1) the release of contaminants into the environment; 2) their movement through and transfer between various environmental media [i.e., subsurface (vadose and saturated zones), surface water, overland (surface soil), and atmospheric]; 3) exposure to surrounding receptors via inhalation, ingestion, dermal contact, and external dose; and 4) risk to carcinogens and hazard to noncarcinogens. The MEPAS model follows ICRP/NCRP and EPA guidelines, where the user is allowed to choose the appropriate guidelines.

5.8.1 No Action Alternative

The only release directly to the surface water in the No Action Alternative was associated with the 105-KE and 105-KW basins. The 105-KE and 105-KW basins were combined as one release and represented by a "single liquid release point to the Columbia River" (Bergsman 1995). The annual liquid discharge is assumed to be 1.4E+06 cubic meters per year (3.7E+08 gallons per year), with a total activity of approximately 0.4 Ci: 0.26 Ci tritium, 0.066 Ci cobalt-60, 0.01 Ci cesium-137, 0.0010 Ci strontium-90, and 9.2E-06 Ci plutonium-239 (Bergsman 1995). All of the constituents in this assessment are radionuclides. The release is assumed to continue at this level over the period of 18 years from 1997 through 2015. Operational liquid effluents from the K Basins are discharged to the Columbia River via the monitored and regulated National Pollutant Discharge Elimination System (NPDES) permitted 1908-KE outfall. Contaminant migration is from the point-source discharge point to the Columbia River, and in the Columbia River to receptors downstream. The flow discharge in the Columbia River is assumed to be under low-flow conditions of 1,000 cubic meters per second (36,000 cubic feet per second) (Whelan et al. 1987), which represents the most conservative case for maximizing surface water concentrations. As a conservative assumption, the removal of water from the Columbia River is assumed to be 100 meters (328 feet) downstream of the point of entry of the contaminant into the river. The assessment addressed recreational activities (e.g., boating, swimming, and fishing) in the Columbia River and use of the water as a drinking water supply and for bathing, irrigation, etc. The risk of fatal cancer in this scenario considering all pathways was found to be less than one chance in a billion. For more information, refer to Whelan et al. (1994).

Intermittent leakage of water from the K Basins is monitored via onsite groundwater sampling. Although radionuclide concentrations in some of the 100-K area monitoring wells exceed EPA drinking water standards, this condition does not constitute a risk to the public because the groundwater is not used directly for human consumption or food production. Analyses of water from the K area springs, where groundwater enters the Columbia River, indicate that radionuclide levels are below the EPA drinking water standards. Dilution of this seepage in the river flow would further reduce the risk to the downstream population, as indicated by the fact that radionuclide concentrations in the Columbia River at the Richland pump house are orders of magnitude below the drinking water standard (Dirkes et al 1994).

5.8.2 Decentralization Alternative

The Spent Nuclear Fuel Wet Transfer and Storage scenario was documented. The source term represents the maximum potential water releases that would be expected if a secondary containment failure and/or piping leak occurred and went undetected for one month at a state-of-the-art wet storage fuel/transfer facility utilizing water treatment technology now available. Releases resulting from such a failure should not be thought of as operational or planned releases. However, for the purposes of a nonzero release source-term, this scenario addresses those situations where an unexpected release may occur. The source-term information was derived from data related to the operation of the Flourinel and Storage Facility (FAST) at INEL's Chemical Processing Plant (ICPP 666) and is considered to be extremely conservative, given the state-of-the-art engineering practices, monitoring, leak-detection equipment, and surveillance procedures likely to be used at any new SNF facility, such as FAST.

Any new facility would be built using state-of-the-art technologies, including leak detection and water-balance monitoring equipment. This equipment, along with the uncertainties associated with evaporation monitoring, will have a minimum detection sensitivity. It is possible that the new SNF facility could experience a failure that would result in a leak that is below the sensitivity of the detection system. Based on the size of the facility and the current monitoring programs at similar facilities, 5 gallons per day has been established as a conservative value to account for potential undetected leakage from the facility. The nonzero release source term would then exceed what could be expected for a new SNF wet storage or transfer facility. Factors contributing to the conservatism in volume estimates are the design criteria, which state that the new facility will contain leak-detection systems (Hale 1994) and will have a lower surface area [i.e., 2000 square meters (6600 square feet)] available for leakage as compared to FAST [i.e., 3830 square meters (12,560 square feet)] (Hale 1994). For the purposes of this assessment, the entire release is assumed as a point source, which is the most conservative assumption. The concentration data associated with the release were contained in or derived from January 6, 1986 to February 14, 1994 weekly water quality reports for FAST and are considered to be reasonable nonzero release source terms at the 95% confidence level. Although surveillance at the FAST facility occurs daily with radiological surveys occurring weekly, the aqueous release assumes that the liner and/or piping leaks and secondary containment failure go undetected for one month.

The specific radionuclide activities in the release solution are assumed as follows: 280 pCi/L strontium-90, 3360 pCi/L cobalt-60, 160 pCi/L cobalt-57(a), 93 pCi/L cesium-137, and 100 pCi/L antimony-125. All of the constituents in this assessment are radionuclides. Contaminant migration is through the vadose zone through the saturated zone to the Columbia River, and in the Columbia River to receptors downstream. The flow discharge in the Columbia River is assumed to be under low-flow conditions 1000 m3 per second (36,000 cubic feet per second) (Whelan et al. 1987), which represents the most conservative case for maximizing surface water concentrations. As a conservative assumption, the removal of water from the Columbia River is assumed to be 100 meters (328 feet) downstream of the contaminant influent point to the river. The assessment addresses recreational activities (e.g., boating, swimming and fishing) in the Columbia River and use of the water as a drinking-water supply and for bathing, irrigation etc. The risk of fatal cancers considering all pathways was found to be significantly less than one chance in a trillion. For more information, refer to Whelan et al. (1994).

The Decentralization Alternative also includes an operational release scenario to the Hanford 200 Area Treated Effluent Disposal Facility (TEDF). Liquid effluents would be added to the TEDF, which receives liquid effluent from many facilities in the 200 Area. The "Discharge Target" allowable concentrations in the TEDF are presented in Bergsman (1995). Only 380 liters (100 gallons) per day will be discharged to the TEDF basin from this operation, although other facilities unrelated to SNF storage will also be discharging to the basin. For a ponded situation, the maximum outflow from the basin is equal to the transmission rate (i.e., saturated hydraulic conductivity under a unit hydraulic gradient) of the soil immediately below the basin, which is 24 cubic meters per day (6260 gallons per day). To maximize the flow velocity through the vadose zone and the mass flux of contaminant leaving the basin (i.e., concentration x area x flow velocity), the assessment assumes that this facility leaks into the vadose zone over a 4-year period with the infiltration rate limited by the transmission rate of the soil. The discharge from the pond is assumed to last for 4 years from 2002 through 2006.

Based on the movement of the second tritium plume from the Plutonium and Uranium Recovery through Extraction cribs in the 200 Area to Well 699-24-33, a distance of 6 kilometers (4 miles) in a 5-year period (1983 to 1988), the average pore-water velocity (i.e., specific discharge divided by the effective porosity) in the saturated zone was 3.3 meters per day (10.8 feet per day) (Schramke et al. 1994). Davis et al. (1993) performed a more recent analysis and determined the pore-water velocity as 0.02 meters per day (0.08 feet per day) just below the TEDF site, although this is not necessarily indicative of the velocity as the water moves toward the river. Both velocities were initially used in assessing the migration of contamination from the basin to determine the most conservative result with respect to risk. In the final analysis, the highest pore-water velocity of 3.3 meters per day (10.8 feet per day) was used because 1) it is consistent with other assessments at the installation, 2) the contaminants reached the river and receptors earlier, and 3) the resulting exposure analysis provided the more conservative estimate of risk over the 7000-year assessment time frame.

Radionuclides, chemical carcinogens, and noncarcinogens are contained in the waste stream. The concentrations in the TEDF were represented by the discharge target allowable concentrations. Contaminant migration is from the

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a. Cobalt-57 is substituted in the analysis for cobalt-58 because the MEPAS database contains only cobalt-57.

ponded water, through the vadose zone, through the saturated zone to the Columbia River, and in the Columbia River to receptors downstream. The flow discharge in the Columbia River is assumed to be under low-flow conditions of 1000 cubic meters per second (36,000 cubic feet per second) (Whelan et al. 1987), which represents the most conservative case for maximizing surface water concentrations. As a conservative assumption, the removal of water from the Columbia River is assumed to be 100 meters (328 feet) downstream of the point of entry of the contaminant into the river. The assessment addressed recreational activities (e.g., boating, swimming, and fishing) in the Columbia River and use of the water as a drinking-water supply and for bathing, irrigation, etc.

The maximum radionuclide and chemical carcinogenic risks were found to be less than 50 chances in a billion for all of the constituents through all of the exposure routes. Likewise, noncarcinogenic chemical individual doses were found to be below their respective reference doses, except chromium VI, which had a dose about 50 percent higher than the reference dose. Chromium VI had an assigned distribution coefficient (i.e., Kd) of zero (Serne and Wood 1990), which represents the most mobile condition in the vadose zone. For more information, refer to Whelan et al. (1994).

5.8.3 1992/1993 Planning Basis Alternative

Scenarios and consequences relating to water quality would be the same as for the Decentralization Alternative. For more information, refer to Whelan et al. (1994).

5.8.4 Regionalization Alternative

Scenarios and consequences relating to water quality in the Regionalization options would be the same as for water quality aspects in the Decentralization Alternative. For more information, refer to Whelan et al. (1994).

5.8.5 Centralization Alternative

Scenarios and consequences relating to water quality would be the same as for the Decentralization Alternative. For more information, refer to Whelan et al. (1994).

5.9 Ecological Resources

Implications of implementing the alternatives for interim storage of SNF on terrestrial resources, wetlands, aquatic ecosystems, and threatened and endangered species at the Hanford Site are discussed in the following subsections.

5.9.1 No Action Alternative

Implications of implementing the No Action Alternative for interim storage of SNF on terrestrial resources, wetlands, aquatic resources, and threatened and endangered species at the Hanford Site are discussed in the following subsections.

5.9.1.1 Terrestrial Resources. No new SNF facilities would be

constructed at Hanford and there would be no impacts to the terrestrial resources of the Hanford Site beyond those resulting from natural processes of succession and the impacts of ongoing Hanford operations. They would remain as described under Section 4.9.1.

5.9.1.2 Wetlands. No new SNF facility would be constructed; therefore,

no changes to wetlands on the Hanford Site would be expected beyond those changes resulting from natural processes and the impacts of ongoing Hanford operations (see Section 4.9.3).

5.9.1.3 Aquatic Resources. No new SNF facility would be constructed

and the fact that there are no surface water facilities on the SNF facility site indicates that there would be no impacts on the aquatic resources of the Hanford Site other than those changes resulting from natural processes and the impacts of ongoing Hanford operations and they would remain as described in Section 4.9.3.

5.9.1.4 Threatened and Endangered Species. No new SNF facilities would

be constructed and operated at Hanford. Thus, populations of species listed as endangered or threatened, or candidates for such listing by the federal and Washington State governments, or species listed as monitor species by the Washington State government would not be impacted (either directly by displacement or indirectly by habitat alteration) beyond effects resulting from ongoing Hanford operations and natural processes.

5.9.1.5 Radioecology. Releases of radionuclides to the environment are

expected to be on the order of those released in the recent past by site operations (Woodruff and Hanf 1993), and thus will not be accumulated into terrestrial or aquatic ecosystems in concentrations that could cause measurable impacts.

5.9.2 Decentralization Alternative

Implications of implementing the Decentralization Alternative for interim storage of SNF on terrestrial resources, wetlands, aquatic resources, and threatened and endangered species at the Hanford Site are discussed in the following subsections.

5.9.2.1 Terrestrial Resources. This alternative would require the

construction of an SNF facility for fuel management and storage. Most spent fuel from the Hanford Site would be stored here.

Construction of an SNF facility at Hanford would disturb up to 9 hectares (24 acres) on the 65 hectare (160 acres) site, representing about 0.01 percent of the total area of the Hanford Site. Approximately 9 hectares (24 acres) would be occupied by facilities, access roads, or rights-of-way and therefore, would remain developed for the life of the project. The remaining land would be revegetated with native grasses and shrubs upon completion of construction.

Vegetation within construction areas would be destroyed during land-clearing activities. Plant species that are dominant on the Hanford SNF site, and thus would be most affected, include big sagebrush, cheatgrass, and Sandberg's bluegrass. Total area destroyed would amount to about less than 1 percent of this community on the Hanford Site. Although the plant communities to be disturbed are well-represented on the Hanford Site, they are relatively uncommon regionally because of the widespread conversion of shrub-steppe habitats to agriculture. Disturbed areas are generally recolonized by cheatgrass, a nonnative species, at the expense of native plants. Mitigation of these impacts could include minimizing the area of disturbance and revegetating with native species, including shrubs, and establishing a 2:1 acreage replacement habitat in concert with a habitat enhancement plan presently being developed for the Hanford Site in general. Adverse impacts to vegetation on Hanford are expected to be limited to the project area and vicinity and are not expected to affect the viability of any plant populations on the Hanford Site.

Construction of an SNF facility and support facilities would have some adverse affect on animal populations. Less mobile animals such as invertebrates, reptiles, and small mammals within the project area would be destroyed during land-clearing activities. Larger mammals and birds in construction and adjacent areas would be disturbed by construction activities and would move to adjacent suitable habitat, and these individual animals might not survive and reproduce. Project facilities would displace about 9 hectares (up to 24 acres) of animal habitat for the life of an SNF facility. Revegetated areas (e.g., construction laydown areas and buried pipeline routes) would be reinvaded by animal species from surrounding, undisturbed habitats. The adverse impacts of construction are expected to be limited to the project area and vicinity and should not affect the viability of any animal populations on the Hanford Site because similar suitable habitat would remain abundant on the site.

Very small quantities of radionuclides would be released to the atmosphere during SNF facility operations. No organisms studied to date are reported to be more sensitive than man to radiation (NRC-8). Therefore, as concluded for humans, the effects of these releases on terrestrial organisms are expected to be minor.

These impacts to the vegetation and animal communities could be mitigated by minimizing the amount of land disturbed during construction, employing soil erosion control measures during construction activities, and revegetating disturbed areas with native species. These measures would limit the amount of direct and indirect disturbance to the construction area and surrounding habitats and would speed the recovery process for disturbed lands.

Operational impacts to terrestrial biotic resources would include exposure of plants and animals to small amounts of radionuclides released during operation of the SNF facility. The levels of radionuclide exposure would be below those levels that produce adverse effects.

5.9.2.2 Wetlands. No wetlands occur on or near the SNF facility site,

so no impacts from the construction and operation of the facility to wetlands would occur. Wetlands resources on the Hanford Site would remain as described in Section 4.9.2. No mitigation efforts would be required because no wetlands would be affected.

5.9.2.3 Aquatic Resources. No aquatic habitats occur on the SNF site;

thus, no impacts to aquatic resources are expected from the construction and operation of the SNF facility. No mitigation efforts would be required because no impacts are anticipated to aquatic resources.

5.9.2.4 Threatened and Endangered Species. Construction and operation

of the SNF facility would remove approximately 9 hectares (24 acres) of relatively pristine big sagebrush/ cheatgrass-Sandberg's bluegrass habitat. This sagebrush habitat is considered priority habitat by the State of Washington because of its relative scarcity in the state and its use as nesting/ breeding habitat by loggerhead shrikes, sage sparrows, sage thrashers, burrowing owls, pygmy rabbits, and sagebrush voles. Bald Eagles, peregrine falcons, and Oregon silverspot butterflies do not inhabit the potential proposed site.

Loggerhead shrikes, listed as a federal candidate (Category 2) and state candidate species, forage on the proposed SNF site and are relatively common on Hanford. This species is sagebrush-dependent, as it is known to select primarily tall big sagebrush as nest sites. Construction of the SNF facility would remove big sagebrush habitat which would preclude loggerhead shrikes from nesting there. SNF site development would also be expected to reduce the value of the site as foraging habitat for shrikes known to nest in adjacent areas.

Sage sparrows and sage thrashers, both state candidate species, occur in mature sagebrush/ bunchgrass habitat at Hanford. Sage thrashers were not observed on the SNF site, and are extremely rare on the Hanford Site. These species are known to nest primarily in sagebrush. Construction of the SNF facility would preclude both of these species nesting there and reduce the site's suitability as foraging habitat for these species.

SNF construction is not expected to substantially decrease the Hanford population of loggerhead shrike, sage sparrow, or sage thrashers because similar sagebrush habitat is still relatively common on the Hanford Site. However, the cumulative effects of constructing the SNF facility, in addition to future developments that further reduce sagebrush habitat (causing further fragmentation of nesting habitat), could negatively affect the long-term viability of populations of these species on the Hanford Site.

Burrowing owls, a state candidate species, are relatively common on the Hanford Site and nest in abandoned ground squirrel burrows on the proposed SNF site. SNF construction would remove sagebrush and disturb soil, displacing ground squirrels and thus reducing the suitability of the area for nesting by burrowing owls. Construction would also displace small mammals, which constitute a portion of the prey base for this species. Construction for an SNF facility would, however, not be expected to negatively impact the viability of the population of burrowing owls on Hanford, as their use of ground squirrel burrows as nests is not limited to burrows in big sagebrush habitat.

Pygmy rabbits, a federal candidate (Category 2) and state threatened species, are known to utilize tall clumps of big sagebrush habitat throughout most of their range. However, this species has not recently been observed on the Hanford Site. Construction of the SNF facility would therefore reduce the potential for recolonization by this species by removing habitat suitable for its use.

Sagebrush voles, a state monitor species, are common on the Hanford Site and select burrow sites near sagebrush; however, this species is common only at higher elevations around the Hanford Site. Construction of the SNF facility would remove sagebrush habitat, precluding sagebrush voles from utilizing the site. However, construction would not affect the overall viability of sagebrush vole populations on the Hanford Site because the majority of the population is found on the Fitzner/Eberhardt Arid Lands Ecology Preserve.

The closest known nests of ferruginous hawks, a federal candidate (Category 2) and state threatened species, and Swainson's hawk, a state candidate, are 8.5 km (5 mi) and 6.2 km (3.7 mi), respectively, from the proposed SNF site. The SNF site comprises a portion of the foraging range of these hawks. Construction of the SNF facility is not expected to disrupt the nesting activities of these species. However, construction would displace small mammal populations and thus reduce the prey for these birds. The cumulative effects of constructing the SNF facility, in addition to future reductions in sagebrush habitat (causing further fragmentation of foraging habitat), could negatively affect the long-term viability of populations of these two species on Hanford.

5.9.2.5 Radioecology. Releases of radionuclides to the environment are

expected to be below those currently released by site operations (Woodruff and Hanf 1993), and thus will not be accumulated into terrestrial or aquatic ecosystems in concentrations that could cause measurable impacts.

5.9.3 1992/1993 Planning Basis Alternative

The 1992/1993 Planning Basis Alternative differs from the Decentralization Alternative only in that TRIGA fuel currently stored at the Hanford Site would be shipped to INEL for storage. (It is possible that the TRIGA fuel may be transferred to third parties for beneficial use prior to the planned time of shipment to INEL.) Thus, impacts on terrestrial resources, wetlands, aquatic resources, threatened and endangered species, and radioecology at the Hanford Site would be essentially the same as described for the Decentralization Alternative.

5.9.4 Regionalization Alternative

All new facilities would be constructed on the 65 hectare (163-acre) site west of 200-East Area (Figure 4.1). Although impacts on terrestrial resources are expected to be minimal, the impacts that would occur would be roughly proportional to the amount of land that would be disturbed during construction. For the various options of the Regionalization Alternative, those areas would amount to the following amounts of land:

A) From about 2 to 7 hectares (5 to 18 acres) when all SNF except defense production SNF would be sent to INEL.

B1) From about 15 to 17 hectares (38 to 43 acres) when all SNF west of the Mississippi River except Naval SNF would be sent to Hanford.

B2) From about 25 to 28 hectares (63 to 70 acres) when all SNF west of the Mississippi River and Naval SNF would be sent to Hanford.

C) From about 2 to 5 hectares (5 to 12 acres) when all Hanford SNF would be sent to INEL or NTS.

While the largest area cited above (28 hectares) is about three times the size of the area to be disturbed in the Decentralization Alternative, it is still a very small fraction of similar habitat on the Hanford Site. By and large the discussion on flora and fauna presented in Section 5.9.2 applies to the Regionalization Alternative, bearing in mind that the area involved would be more or less depending on the option chosen.

5.9.5 Centralization Alternative

If Hanford is selected as the site for the Centralization Alternative, an SNF facility, as substantially described in the Decentralization Alternative, would be constructed at Hanford. Although the facility would store about 25 weight percent more SNF than would be stored under the Decentralization Alternative and the number of casks would increase the required space, the ecological impacts would be essentially the same as those described in Section 5.9.2.

If Hanford is not selected as the site for the Centralization Alternative, an SNF packaging facility would be built to prepare the fuel for shipment offsite. While that facility would not be as extensive as the SNF facility, the ecological impacts would not likely be importantly different from those described in Section 5.9.3 for the Decentralization Alternative.

5.10 Noise

Implications of implementing the alternatives for interim storage of SNF on noise levels at the Hanford are discussed in the following subsections.

5.10.1 No Action Alternative

Under this alternative, new SNF facilities would not be constructed, and the noise associated with SNF facility construction and operation activities would not occur. Because no major changes in existing noise-emitting sources are expected at Hanford during the projected SNF facility construction period, the ambient noise levels at Hanford would be expected to remain essentially the same for the no-action alternative as during the baseline period.

5.10.2 Decentralization Alternative

This alternative would require the construction and operation of an SNF facility for fuel management and storage. Most spent fuel from the Hanford Site would be stored here. The results of a detailed analysis of the potential noise impacts from constructing and operating a new production reactor (project since cancelled) and its support facilities at Hanford have been published. The analysis indicates that noise from constructing a facility the size of a production reactor, and from operational facilities, equipment, and machines, would not cause ambient noise levels to exceed the limits set by the Washington State noise control regulations or EPA guidelines. The latter are set to protect the public from the effect of broadband environmental noise and to protect the public against hearing loss. The results also indicate that increases in noise levels from constructing and operating a facility the size of a production reactor and its support facilities, including increased traffic along the major roadways, would result in little or no increase in the annoyance level experienced by communities or individuals.

No significant noise impacts from activities associated with SNF facility construction and operation are expected at sensitive receptor locations outside the Hanford boundary or at residences along the major highways leading to the proposed SNF site at Hanford.

5.10.3 1992/1993 Planning Basis Alternative

The 1992/1993 Planning Basis Alternative differs from the Decentralization Alternative only in that TRIGA fuel currently stored at the Hanford Site would be shipped to INEL for storage. (It is possible that the TRIGA fuel may be transferred to third parties for beneficial use prior to the planned time of shipment to INEL.) Thus, impacts would be essentially the same as described for the Decentralization Alternative.

5.10.4 Regionalization Alternative

All new facilities would be constructed on the 65 hectare (163-acre) site west of 200-East Area (Figure 4.1). Although noise is not expected to be a factor in evaluating the alternatives, the amount and duration of noise associated with construction would be roughly proportional to the amount of land that would be disturbed during construction. For the various options of the Regionalization Alternative, those areas would amount to the following amounts of land:

A) From about 2 to 7 hectares (5 to 18 acres) when all SNF except defense production SNF would be sent to INEL.

B1) From about 15 to 17 hectares (38 to 43 acres) when all SNF west of the Mississippi River except Naval SNF would be sent to Hanford.

B2) From about 25 to 28 hectares (63 to 70 acres) when all SNF west of the Mississippi River and Naval SNF would be sent to Hanford.

C) From About 2 to 5 hectares (5 to 13 acres) when all Hanford SNF would be sent to INEL or NTS.

Although not likely to be heard offsite, the duration of noise that is generated would range from about a quarter to three times that described for the Decentralization Alternative depending on the Regionalization option chosen.

5.10.5 Centralization Alternative

If Hanford is selected as the site for centralization of SNF, new SNF facilities would be constructed at Hanford. Although somewhat larger than for the Decentralization Alternative, the impacts from noise would be the same as those described in Subsection 5.10.2.

5.11 Traffic and Transportation

The implications of implementing the alternatives for interim storage of SNF on traffic and incident-free onsite transportation of SNF and materials supporting SNF storage at the Hanford are discussed in the following subsections. The impacts of offsite transportation of SNF are discussed in

Appendix I.

5.11.1 No Action Alternative

Implications of implementing the No Action Alternative for interim storage of SNF on traffic and incident-free onsite transportation of SNF and materials supporting SNF storage are discussed in the following subsections.

5.11.1.1 Traffic. Under the No Action Alternative, the number of

workers would stay the same as under present conditions; therefore, there would be no change in traffic patterns. At present, there are periods of moderate traffic congestion, some of which is expected to be alleviated by a new road to the 200 areas.

5.11.1.2 Transportation. The RISKIND (Yuan et al. 1993) and RADTRAN 4

(Neuhauser and Kanipe 1992) computer codes were applied to calculate the radiation doses to transport workers and the public that are estimated to result from incident-free onsite transportation of SNF. RISKIND was also used to calculate the consequences of bounding transportation accidents. All of the onsite SNF shipments were assumed to emit radiation that would result in a dose rate at the regulatory limit (i.e., 0.01 rem per hour at 2 meters (6 feet) from the external surface of the shipments). This assumption contributes to the conservatism of the analysis because the shipment dose rates cannot be larger than this value but frequently will be substantially smaller. All shipments were assumed to be made by truck. A detailed description of the approach and other important shipment-related parameters are discussed in Volume 2, Chapter 5, and Appendix I. Hanford-specific information and input parameters are presented in this section.

The doses per incident-free shipment of each type of SNF were calculated using RISKIND and RADTRAN 4. The potential receptors considered are the transportation crew of two, on-link (on the road) and off-link (persons near the roadway) populations. Guards and/or inspectors may also be exposed to the shipments. Guards and inspectors may be exposed when they prepare a shipment to leave its origin facility or prepare to receive a shipment that has arrived at a destination facility. Guards and inspectors may also be exposed while the shipment is enroute between facilities. Guard and inspector doses at origin and destination facilities are included in the doses calculated in Section 5.13. Most onsite shipments originate in the 200 and 100 Areas and will not travel through a guarded checkpoint. The guard/inspector doses for these shipments are zero. Only the miscellaneous fuel shipments originating in the 300 Area and the FFTF shipments originating in the 400 Area will travel past a guarded checkpoint (see Wye Barricade in Section 4.11). Doses to the guards at the Wye Barricade were calculated assuming they were exposed briefly at a distance of 5 meters, (16 feet) from the shipment, as described in Volume 2, Chapter 5. The computer code RISKIND was used to calculate maximum and individual doses; RADTRAN 4 was used to calculate collective population doses.

Five general classes of SNF were considered in this analysis. These include N Reactor fuel, FFTF fuel, single-pass reactor (SPR) fuel, PWR Core-II fuel, and miscellaneous fuel. A sixth type of fuel, fuel wastes in EBR-II metal casks, was assumed to have similar shipping characteristics to miscellaneous fuels. Some of the key shipment characteristics for these fuels are presented in Table 5.11-1, including the SNF material forms, quantities, shipment capacities, and numbers of shipments. Radionuclide inventories for the various types of fuel shipments are provided in Table 5.11-2. The radionuclide inventories were derived from the irradiated fuel inventories and characteristics provided by Bergsman (1994, 1995) and the shipment characteristics listed in Table 5.11-2.

The population densities of the different areas of the Hanford Site across which shipments must travel will influence the transportation impacts. Doses to persons along the highways (i.e., off-link doses) will be received only by Hanford Site workers for onsite shipments.

Table 5.11-1. Spent nuclear fuel shipment characteristics.

Fuel Type	Material Form	Quantity, Assemblies	Shipment Capacity, Assemblies/shipment	Number of Shipmentsa

N Reactor	Uranium metal clad with Zircalloy-2	Short: 66,300 Long: 63,700	Short: 128 Long: 96	Short: 518 Long: 664 Total: 1,182
FFTF	Mixed uranium-plutonium oxide in stainless steel tubes	317	4	80
Single-pass reactor	Uranium metal enclosed in aluminum jackets	1,100	900	2
PWR Core-II	Natural uranium oxide clad in zirconium alloy	72	1	71
Fuel wastes in EBR-II metal casks	Plutonium-uranium compounds sealed in stainless steel canisters	24 casks	1 cask per shipment	24
Miscellaneous	Various uranium compounds from research and development programs	77	4	20

a. This column provides the number of onsite shipments projected to occur in the Decentralization, 1992/1993 Planning Basis, Regionalization, and Centralization Alternatives. For the No-Action Alternative, one shipment of N Reactor fuel currently at PUREX and all of the miscellaneous fuels were assumed to be transported onsite.

Table 5.11-2. Radionuclide inventories for shipments of each type of spent nuclear fuel on the Hanford Site (Ci/shipment). ,b

Radio-nuclide	FFTF	N Reactor	PWR Core-II fuel	Single-pass reactor	EBR-II/ Misc.c
H-3	2.1E+02	3.9E+03	1.6E+02	3.9E+03	0.0E+00
Mn-54	7.0E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Fe-55	6.9E+02	1.1E+03	6.1E+03	1.1E+03	0.0E+00
Co-60	7.3E+02	7.9E+02	4.2E+03	7.9E+02	4.3E+02
Ni-63	6.0E+01	0.0E+00	2.7E+03	0.0E+00	0.0E+00
Kr-85	1.8E+03	7.5E+04	1.6E+03	7.5E+04	6.3E+02
Sr-90	1.3E+04	8.7E+05	1.8E+04	8.7E+05	3.1E+02
Y-90	1.3E+04	8.7E+05	1.8E+04	8.7E+05	3.1E+02
Ru-106	1.8E+04	7.1E+03	2.9E+02	7.1E+03	1.4E+03
Rh-106	1.8E+04	7.1E+03	2.9E+02	7.1E+03	1.4E+03
Sb-125	3.7E+03	1.6E+04	1.1E+03	1.6E+04	0.0E+00
Te-125m	9.1E+02	4.3E+03	2.6E+02	4.3E+03	0.0E+00
Cs-134	5.2E+03	1.9E+04	1.6E+03	1.9E+04	0.0E+00
Cs-137	3.6E+04	1.1E+06	3.6E+04	1.1E+06	3.5E+03
Ba-137m	3.4E+04	1.0E+06	3.4E+04	1.0E+06	3.3E+03
Ce-144	6.3E+03	4.1E+03	0.0E+00	4.1E+03	9.6E+03
Pr-144	6.3E+03	4.1E+03	0.0E+00	4.1E+03	9.6E+03
Pr-144m	7.6E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Pm-147	2.8E+04	2.9E+05	4.5E+03	2.9E+05	7.7E+03
Sm-151	1.4E+03	1.3E+04	1.9E+02	1.3E+04	0.0E+00
Eu-154	1.0E+03	1.3E+03	2.1E+03	1.3E+03	0.0E+00
Eu-155	3.2E+03	4.8E+03	7.6E+02	4.8E+03	6.4E+01
U-233	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.3E-01
U-234	0.0E+00	1.5E+00	0.0E+00	1.5E+00	2.1E+01
U-235	2.0E-04	6.7E-02	0.0E+00	6.7E-02	2.6E-02
U-238	2.7E-02	1.0E+00	0.0E+00	1.0E+00	3.3E-04
Np-237	4.6E-02	3.5E-02	0.0E+00	3.5E-02	0.0E+00
Pu-238	6.6E+02	0.0E+00	1.1E+03	0.0E+00	3.8E+01
Pu-239	1.4E+03	1.8E+02	2.8E+02	1.8E+02	6.9E+01
Pu-240	1.5E+03	4.5E+01	3.7E+02	4.5E+01	2.0E+02
Pu-241	6.3E+04	1.7E+03	6.8E+04	1.7E+03	1.1E+04
Pu-242	5.2E-01	3.0E-03	0.0E+00	3.0E-03	6.9E-01
Am-241	8.0E+02	3.1E+01	1.6E+03	3.1E+01	0.0E+00
Cm-243	4.6E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cm-244	8.8E+01	0.0E+00	7.9E+02	0.0E+00	0.0E+00

a. Radionuclide inventory data were derived from information in Bergsman (1994) and WHC (1993c).

b. For radionuclides that are indicated to have 0.0 Ci per shipment, the quantities of fission and activation are less than 5 Ci/assembly and less than 10 g/assembly for actinides. Radionuclides not listed on the table are also less than these quantities.

c. Fuel inventories for EBR-II casks are assumed to be applicable to miscellaneous fuels. The SNF in EBR-II casks and miscellaneous SNF consist primarily of irradiated light-water reactor fuels.

The population densities for each work area on the site, used for occupational dose calculations, are listed in Table 5.11-3. The off-link doses are included in the occupational dose results.

For the calculation of doses to persons traveling on the highways (i.e., on-link doses), two-lane highways were assumed and the number of persons per vehicle was assumed to be 2.0. No vehicle stops were included in the calculations because the shipments are not long enough to warrant intermediate stops for food and rest. One-way traffic densities were based on traffic counts provided in DOE (1989). Because average traffic densities were not available in that document and there are no administrative restrictions on time of day when SNF transport could occur, the peak count on a given route segment (vehicles per day) was used to calculate the traffic density for that route. The traffic densities used for the five types of SNF and shipping distances for the various fuel types are provided below.

- FFTF Fuel - 640 vehicles per hour; 28 kilometers one-way shipping distance
- N Reactor Fuel - 170 vehicles per hour; 16 kilometers one-way shipping distance
- PWR Core II Fuel - 180 vehicles per hour; 5 kilometers one-way shipping distance
- Single-pass Reactor Fuel - 100 vehicles per hour; 16 kilometers one-way shipping distance
- EBR-II/300 Area Miscellaneous Fuel - 640 vehicles per hour; 37 kilometers one-way shipping distance.

Table 5.11-3. Population densities for work areas at Hanford.

Work Area	Worker Population	Land Area, km2	Worker Density, per km2
100 B and C	4	1.7	3
100 D and DR	4	1.5	3
100 H	4	0.7	6
100 K	124	0.9	140
100 N	360	1.0	360
200 West	1968	9.5	210
200 East	2923	9.0	330
300	2487	1.5	1700
400	638	2.1	300
600	514	1450	0.35
WPPSS	1125	4.4	260

The computer code RISKIND was used to calculate the doses to Maximally-Exposed Individual (MEI) members of the public as discussed in Volume 2, Chapter 5. Two exposure scenarios were modeled, including a "tailgater" and a "bystander." The dose received by a tailgater was calculated by assuming that an individual precedes or follows an SNF shipment for the entire duration of a shipment. The exposure distance was assumed to be 48.8 meters (160 feet). The dose calculated in Volume 2, Chapter 5, was based on a 37 kilometers (23 miles) shipping distance, which is also the same as the longest shipping distance anticipated for SNF shipments at Hanford (300 Area to the 200 Area). Therefore, the public MEI dose amounts to 0.015 millirem per tailgating incident.

The dose to a "bystander" was calculated in Volume 2, Chapter 5, to be 0.0014 millirem. This dose was calculated assuming a shipment passes by an individual at an average speed of 56 kilometers per hour (35 miles per hour) at a distance of 1 meter (3 feet) from the shipment. This individual was postulated to be standing on the side of the road as an SNF shipment passes by and was assumed to be exposed only one time.

The dose to the maximally-exposed worker from incident-free transportation will be received by the truck crew. The dose to the truck crew was calculated using the maximum allowable dose rate in the truck cab (2 millirem per hour) for all shipments. It was assumed that the maximum-exposed worker will accompany all of the spent fuel shipments, even though the dose will most likely be apportioned over a larger number of workers. The total dose received by this individual was calculated by multiplying the maximum dose rate by the total shipping time. The total shipping time for the various alternatives was determined by dividing their total shipping distances by the average speed, 56 kilometers per hour (35 miles/hour).

The results of the analysis of the No Action Alternative are presented in Table 5.11-4. As shown, two shipment campaigns occur in this alternative; 1) shipment of N Reactor fuels at PUREX to the 105-K basins for storage and 2) shipment of miscellaneous SNF in the 300 Area to the 200 Area to be placed in dry storage. The total radiological impacts from incident-free transportation in this alternative are dominated by the shipments of miscellaneous fuels from the 300 Area to the 200 Area. This is primarily because there are approximately 24 shipments of miscellaneous fuels, and the N Reactor fuel at PUREX will make up only a fraction of a shipment.

Table 5.11-4. Impacts of incident-free transportation for the No Action Alternative.

Impacts[b]	General Population[c]	Occupational
Total Dose (person-rem)	7.8E-02	1.2E-01
Cancer Fatalities	3.9E-05	4.7E-05

a. The N Reactor fuel currently at PUREX is the only N Reactor fuel transported in this alternative. The impacts of transporting this fuel were calculated by adjusting the impacts of transporting all N Reactor fuel (0.3 MTHM at PUREX/2096 MTHM total N Reactor fuel).

b. Total detriment, which includes latent cancer fatalities, nonfatal cancers, and genetic effects in subsequent generations, can be calculated by multiplying the total dose to the general population by 7.3E-04 effects per person-rem and the total occupational dose by 5.6E-04 effects per person-rem.

c. Rural population density.

The doses to the maximally-exposed workers and members of the public are summarized below:

- The dose to a tailgater was calculated to be 0.015 millirem.
- The dose to a bystander was calculated to be 0.0014 millirem.
- The dose to a truck crewman that accompanies all of the spent fuel shipments in the No Action Alternative was calculated to be about 46 millirem.

The RISKIND computer code was used to calculate the radiological consequences of accidental releases of radioactive material during transportation. Consequences of severe, reasonably foreseeable accidents were calculated to workers and the offsite population. Workers were placed at a distance that maximizes the dose from a potential release. Hanford-specific population density data (see Beck et al. 1991) were used to assess the integrated doses to the offsite public, as described in Volume 2, Chapter 5.

As discussed in Appendix I, maximum radiological impacts were calculated for a severe, reasonably foreseeable accident. For this assessment, the consequences were assessed to populations and individuals assuming the most severe accident scenario with a probability greater than 1E-07. The methods and data described in Appendix I were used to calculate the accident probabilities of the various shipments in the No Action Alternative. Hanford-specific numbers of shipments and shipping distances were used in the calculations. Accident rate information from Saricks and Kvitek (1991) for urban areas in the State of Washington were used in the calculations. The results of these calculations indicate that the probabilities of the severe accident defined in Appendix I for the irradiated fuels transported in the No Action Alternative are less than the 1E-07 criteria. The most likely severe accident scenario was determined to be one involving shipments of miscellaneous fuels from the 300 Area. The probability of such an accident was calculated to be about 1E-09. As shown in Table 5.11-5, this is also the highest-consequence accident scenario for the No Action Alternative.

The impacts of potential severe transportation accidents for the No Action Alternative are shown in Table 5.11-5. The maximum exposed individual and public collective doses are shown in Table 5.11-5 for shipments of miscellaneous SNF in the 300 Area to dry storage in the 200 Area. This was determined to be the most severe reasonably foreseeable onsite transportation accident scenario for the No Action Alternative, even though its probability is significantly smaller than 1E-07, as discussed above. As shown, consequence estimates are presented for two atmospheric dispersion conditions; 1) neutral (Pasquill stability class D, wind speed = 4 meters per second) and 2) stable (Pasquill stability class F , wind speed = 1 meters per second).16

Table 5.11-5. Impacts of accidents during transportation for the No Action Alternative.

Dose Consequence

Cancer Fatalities

Point Estimate of Risk

Exposure Group

Stability Category

Stability Category

Stability Category

	D	F	D	F	D	F
Offsite Population[b]	1.4E+01 person-rem	1.1E+02 person-rem	6.8E-03	5.5E-02	6.8E-12	5.5E-11
Maximum Exposed Individual	5.0E-01 rem	1.7E+00 rem	2.0E-04	6.7E-04	2.0E-13	6.7E-13

a. The maximum-consequence onsite transportation accident for the No Action Alternative is one involving a shipment of miscellaneous fuels currently located in the 300 Area. This is also the most likely accident scenario, but its probability is below the 1E-07 criteria for a maximum reasonably foreseeable accident.

b. Rural population density.

Nonradiological impacts consist of fatalities that may result from traffic accidents as well as health effects from pollutants emitted from vehicles involved in onsite shipments of spent nuclear fuel. These risks are unrelated to the radioactive nature of the materials being transported. Nonradiological impacts from accidents were calculated using unit risk factors derived by Saricks and Kvitek (1991) that convey the estimated number of fatalities per unit distance traveled. The total nonradiological impacts are calculated by multiplying the total shipping distance traveled by onsite shipments by the appropriate unit risk factors.

The total nonradiological transportation impacts for the No Action Alternative were calculated to be less than one (1.9E-05) fatality.

5.11.2 Decentralization Alternative

Implications of implementing the Decentralization Alternative for interim storage of SNF on traffic and incident-free onsite transportation of SNF and materials supporting SNF storage are discussed in the following subsections.

5.11.2.1 Traffic. Under the Decentralization Alternative, the number of construction workers would range from about 220 to 870. During operations, the number of workers would range from about 1100 to 1300, depending on the option selected. This would add from 1 to 6 percent to the present workforce and to additional commuting traffic on the Hanford Site, assuming that the proportion of workers that take the bus to work or drive their own vehicles remains essentially constant.

5.11.2.2 Transportation. The same approaches and basic assumptions and data described in Section 5.11.1.2 for the No Action Alternative were used to assess the impacts of onsite transportation for the Decentralization Alternative. The key differences between the alternatives are the numbers of shipments and destinations. More SNF is transported in this alternative than in the No Action Alternative. In this alternative, all N Reactor SNF in the 105-K Basins is to be transported to the 200 Area for processing and/or storage, depending upon the particular suboption selected. The FFTF fuel is to be transported from the 400 Area to the 200 Area for storage. The PWR Core-II, single- pass reactor fuels, and 300 Area miscellaneous fuels are also to be transported to a new facility in the 200 Area for storage.

Table 5.11-6 presents the incident-free transportation impacts for the Decentralization Alternative. As shown in Table 5.11-6, the truck crews are the largest exposure group. The total doses were found to be dominated by the exposures received during transportation of N Reactor fuel. This is because there are significantly more truck shipments of N Reactor fuel in this alternative than shipments of other types of fuel.

The doses to the maximally-exposed workers and members of the public are summarized below:

- The dose to a tailgater was calculated to be 0.015 millirem.

- The dose to a bystander was calculated to be 0.0014 millirem.

- The dose to a truck crewman that accompanies all of the spent fuel shipments in the Decentralization Alternative was calculated to be about 800 millirem.

The worker MEI dose is higher than that calculated for the No Action Alternative because there are many more onsite spent fuel shipments in the Decentralization Alternative.

Table 5.11-7 presents the impacts of potential severe transportation accidents for the Decentralization Alternative. The maximum exposed individual and public collective doses are shown in Table 5.11-7 for two accident scenarios: the highest probability and highest consquence. As explained in the table footnotes, the probabilities of both scenarios are less than MEI 1E-07 criteria discussed in Appendix I. As shown, consequence estimates are presented for two atmospheric dispersion conditions; 1) neutral (Pasquill stability class D, wind speed = 4 meters per second) and 2) stable (Pasquill stability class F , wind speed = 1 meters per second). This table is different from Table 5.11-5 (No Action Alternative) because of the additional fuel types transported in the Decentralization Alternative.

Table 5.11-6. Impacts of incident-free transportation for the Decentralization Alternative.

Impacts[a]	General Population[b]	Occupational
Total Dose (person-rem)	4.3E-01	1.7E+00
Cancer Fatalities	2.2E-04	6.8E-04

a. Total detriment, which includes latent cancer fatalities, non-fatal cancers, and genetic effects in subsequent generations, can be calculated by multiplying the total dose to the general population by 7.3E-04 effects per person-rem and the total occupational dose by 5.6E-04 effects per person-rem.
b. Rural population density.

Table 5.11-7. Impacts of accidents during transportation for the Decentralization Alternative.

Accident Scenario	Exposure Group	Dose Consequence		Cancer Fatalities		Point Estimate of Risk	
		Stability Category		Stability Category		Stability Category	
		D	F	D	F	D	F
Highest Probability[a]	Offsite Population[b]	1.7E+01 Person-rem	1.4E+02 Person-rem	8.6E-03	6.8E-02	4.3E-10	3.4E-09
	Maximum Exposed Individual	7.2E-01 Rem	2.4E+00 Rem	2.9E-04	9.6E-04	1.4E-11	4.8E-11
Highest Consequence[c]	Offsite Population	1.7E+02 Person-rem	1.3E+03 Person-rem	8.4E-02	6.7E-01	5.0E-10	4.0E-09
	Maximum Exposed Individual	5.4E+00 Rem	1.8E+01 Rem	2.2E-03	7.2E-03	1.3E-11	4.3E-11

a. The highest-probability accident is one involving a shipment of N Reactor fuel. The probability of this accident scenario was calculated to be approximately 5E-8 over the entire N-Reactor fuel shipping campaign.
b. Rural population density.
c. The highest-consequence accident scenario was determined to be one involving shipments of FFTF fuel. However, the probability of the accident scenario analyzed here is approximately 6E-09, which is below the 1E-07 probability criteria for a reasonably foreseeable accident.

The total nonradiological transportation impacts for the Decentralization Alternative were calculated to be 6.6E-04 fatalities. The nonradiological transportation impacts of this alternative are significantly higher than the impacts of the No Action Alternative because the numbers of shipments, and thus total shipment mileage, is significantly higher.

5.11.3 1992/1993 Planning Basis Alternative

Implications of implementing the 1992/1993 Planning Basis Alternative for interim storage of SNF on traffic and incident-free onsite transportation of SNF and materials supporting SNF storage are discussed in the following subsections.

5.11.3.1 Traffic. Because the only difference between the

Decentralization Alternative and the 1992/1993 Planning Basis Alternative is the shipment of the small amount of TRIGA fuel offsite, traffic patterns would not be significantly different from those described for the Decentralization Alternative.

5.11.3.2 Transportation. The impacts of onsite transportation for the

1992/1993 Planning Basis Alternative are substantially the same as the impacts of the Decentralization Alternative (see Section 5.11.2). The only difference between these two alternatives is the disposition of the TRIGA fuel in the 308 Building. The quantity and number of TRIGA fuel shipments is small relative to the other fuel types so the disposition of the TRIGA fuels will have a negligible impact on the results presented in Tables 5.11-3 and 5.11-4.

5.11.4 Regionalization Alternative

Implications of implementing the Regionalization Alternative for interim storage of SNF on traffic and incident-free onsite transportation of SNF and materials supporting SNF storage are presented in this section. The onsite transportation requirements for the four Regionalization Alternative options are as follows:

- Option A - Defense production fuel will be shipped from the 105-K basins and Plutonium and Uranium Recovery through Extraction to a new facility in the 200 Area for storage. All other fuel will be shipped offsite; the transportation impacts of offsite shipments are addressed in Appendix I.

- Option B1 - All SNF located or to be generated west of the Mississippi River will be sent to Hanford for storage, except for Naval SNF. Shipments of SNF from offsite locations are addressed in Appendix I. The onsite SNF will be transported from its current locations to the 200 Area for storage. In terms of onsite transportation impacts, this option is essentially the same as the Decentralization Alternative (see Section 5.11.2).
    - Option B2 - The same as Option B1 except that Naval SNF will also be transported to Hanford. This alternative would result in the same onsite transportation impacts as Option B1.

- Option C - All Hanford SNF will be transported offsite to a facility at INEL or NTS. Offsite transportation impacts are addressed in Appendix I.

5.11.4.1 Traffic. Under the Regionalization Option A, the number of

construction workers would range from about 180 to 1200, depending on the option selected. During operations, the number of workers would range from about 280 to 320, depending on the suboption selected. This would add from less than 1 to about 5 percent to the present workforce and to additional commuting traffic on the Hanford Site, assuming that the proportion of workers that take the bus to work or drive their own vehicles remains essentially constant. Assuming that all of the N Reactor fuel shipments travel 16 kilometers (10 miles) one way (approximate distance from the 100 Areas to the 200 Area), a total of about 40,000 vehicle-kilometers are needed for the N Reactor fuel shipments in this option. It was stated in Section 4.11 that in 1988 DOE vehicles logged over 19,000,000 vehicle-kilometers (12,000,000 vehicle-miles) at Hanford. The increase in vehicle mileage resulting from the Regionalization Option A, assuming that all the Hanford SNF shipments will be made in one year, is less than 1 percent above the 1988 base DOE-vehicle mileage.

For the Regionalization options B1 and B2, the impacts on traffic would be essentially the same as those described for the Decentralization Alternative (see Section 5.11.2.1).

The Regionalization Option C involves offsite shipments of Hanford fuel. The number of Hanford workers would stay approximately the same as the No Action Alternative. The impacts on traffic are predominantly related to the additional vehicles on the highways that are carrying Hanford fuels to INEL or NTS. Assuming that all of the onsite Hanford fuel shipments travel 48 kilometers (30 miles) one way (approximate distance from the 100 Areas to the 300 Area), a total of about 130,000 vehicle-miles are needed for the onsite segments of these shipments. It was stated in Section 4.11 that in 1988 DOE vehicles logged over 12,000,000 miles at Hanford. The increase in vehicle mileage resulting from Regionalization Option C, assuming that all the Hanford fuel shipments will be made in one year, is about 1 percent above the 1988 base DOE-vehicle mileage.

5.11.4.2 Transportation. In Regionalization Option A, all N Reactor

SNF in the 105-K basins and at PUREX would be transported to the 200 Area for processing and/or storage, depending on the particular suboption selected. The FFTF, PWR Core-II, single-pass reactor fuels, and 300 Area miscellaneous fuels are to be transported to INEL. Offsite transportation impacts are addressed in Appendix I. Onsite transportation impacts for this option, therefore, would consist of the impacts of transporting N Reactor fuel from the 105-K basins and PUREX to the 200 Area.

The transportation impacts of this option were calculated by determining the impacts of transporting N Reactor fuel on a per-shipment basis and then multiplying the total number of shipments. The methods and input data described in Section 5.11.1 were used to calculate the per-shipment impacts. The results of the transportation impact calculations for the Regionalization Option A are as follows:

- Incident-free transportation impacts: Public exposures - 2.4E-01 person-rem (9.6E-05 LCFs); Worker exposures - 1.4E+00 person-rem (5.6E-04 LCFs).

- Impacts of transportation accidents: Public, Pasquill Stability Class D - 1.7E+01 person-rem (8.6E-03 LCFs); Public - Pasquill Stability Class F - 1.4E+02 person-rem (6.8E-02 LCFs). Maximum exposed individual, Pasquill Stability Class D - 7.2E-01 rem (2.9E-04 LCFs); Maximum exposed individual Pasquill Stability Class F - 2.9E+00 rem (9.6E-04 LCFs). See the "highest probability" accident in Table 5.11-7.

- Nonradiological impacts: 5.6E-04 fatalities.

The incident-free doses to the maximally-exposed workers and members of the public are summarized below:

- The dose to a tailgater was calculated to be 0.015 millirem.

- The dose to a bystander was calculated to be 0.0014 millirem.

- The dose to a truck crewman who accompanies all of the SNF shipments in Regionalization Option A was calculated to be about 680 millirem.

The worker MEI dose is higher than that calculated for the No Action Alternative because there are many more onsite spent fuel shipments in the Regionalization Option A. The worker MEI dose is lower than that calculated for the Decentralization Alternative because only N Reactor fuel is shipped onsite in Regionalization Option A, and all fuel types are shipped onsite in the Decentralization Alternative.

In Regionalization options B1 and B2, all Hanford SNF would be shipped onsite from its current locations to the 200 Area. Traffic and transportation impacts for both Regionalization options B1 and B2 would be essentially the same as those calculated for the Decentralization Alternative.

In Regionalization Option C, all of the Hanford Site SNF would be shipped to and stored at either INEL or NTS. Because all of the shipments of Hanford SNF would be considered to be offsite shipments, the impacts are addressed in Appendix I. For Hanford, this option is identical to the Centralization Alternative, minimum option.

5.11.5 Centralization Alternative

Implications of implementing the Centralization Alternative for interim storage of SNF on traffic and incident-free onsite transportation of SNF and materials supporting SNF storage are discussed in the following subsections.

5.11.5.1 Traffic. Traffic patterns would be essentially the same as

for the Decentralization Alternative if Hanford were selected to receive all DOE SNF. The patterns would last for up to twice as long because of the additional fuel to be brought to the reprocessing/ stabilization and storage facility (although there is only 25 weight percent more fuel to be shipped, it would likely require smaller quantities per shipment because of its higher heat load). If all Hanford fuel were to be shipped offsite, traffic patterns would not be significantly different from those of the No Action Alternative.

5.11.5.2 Transportation. The Centralization Alternative results in the

same onsite transportation impacts as the Decentralization Alternative. In the Decentralization Alternative, all Hanford Site SNF will be transported to the 200 Areas for further processing and/or storage, depending on the specific option. In the Centralization Alternative, all Hanford Site SNF is transported to either a stabilization/packaging facility in the 200 Area for preparation for offsite shipment or to the Central Storage Facility to be located in the 200 Area. All of these cases requires onsite shipment of Hanford SNF from their current locations to a 200 Area facility. Therefore, the onsite transportation impacts for the Centralization Alternative are the same as those for the Decentralization Alternative (see Section 5.11.2).

5.12 Occupational and Public Health and Safety

Implications of implementing the alternatives for interim storage of SNF on worker and public health and safety at the Hanford Site are discussed in the following subsections. By and large this material consists of summary material extracted from Section 5.7, "Air Quality and Related Consequences;" 5.8, "Water Quality and Related Consequences;" 5.11, "Traffic and Transportation;" and 5.15, "Accidents."

5.12.1 No Action Alternative

Radiological and nonradiological consequences relating to occupational and public health and safety for the No Action Alternative are presented in the following subsections.

5.12.1.1 Radiological Consequences. The consequences of air emissions

from routine operations of existing facilities utilized in the No Action Alternative include a maximum annual dose of 1E-5 rem to a potential onsite worker with a 5E-9 probability of fatal cancer. The collective annual dose to workers in spent fuel storage facilities is 24 person-rem per year (Bergsman 1995), which would require about 60 years of such operation to accumulate a collective worker dose from which one fatal cancer might be inferred.

The dose to an offsite resident at the highest exposure location is estimated as 3E-6 rem/year, and the corresponding probability of fatal cancer is 1E-9.

The peak collective dose to the population within 80 kilometers (50 miles) is 3E-2 person-rem per year, which is predicted to result in less than one fatal cancer (about 36,000 years of such operation would be required to reach a dose from which one fatal cancer might be inferred).

5.12.2 Decentralization Alternative

Radiological and nonradiological consequences relating to occupational and public health and safety for the Decentralization Alternative are presented in the following subsections.

**5.12.2.1 Radiological Consequences. The consequences of air emissions from individual facilities in the Decentralization Alternative are summarized in Table 5.7-8 and include a maximum annual dose of 2E-9 rem to a potential onsite worker (8E-13 probability of fatal cancer) for any combination of wet or dry spent fuel storage facilities. The dose to an offsite resident at the highest exposure location is estimated as 6E-10 rem per year, and the corresponding probability of fatal cancer is 3E-13. The peak collective dose to the population within 80 km is 2E-5 person-rem per year, which is predicted to result in less than one fatal cancer. The collective annual dose to workers at SNF facilities for a combination of wet and dry storage facilities is 2 person-rem per year for maintenance and operations. Loading the new facilities would require an additional 17-18 person-rem depending on the form of dry storage. For dry storage only, the dose from initial loading would be 7-12 person-rem, and there would be no dose from normal operations (Bergsman 1995).

For dry storage of defense fuel, stabilization prior to dry storage is included in the routine operations of the Decentralization Alternative, and additional emissions would result from these activities. The dose to the onsite worker from air emissions would increase by 4E-6 rem/year for a shear/leach/calcine process or 3E-5 rem/year for a solvent extraction process (2E-9 or 1E-8 probability of fatal cancer, respectively). Collective worker dose at fuel stabilization facilities would range from 44 person-rem per year at a shear/ leach/ calcine facility to 78 person-rem per year at a solvent extraction facility over the 4 years in which these facilities are expected to operate (Bergsman 1995). The dose to an individual worker in the facility is assumed to be limited by administrative controls to no more than 0.5 rem per year.

The consequences from stabilization for the offsite resident would be 7E-6 rem per year (4E-9 prob- ability of fatal cancer) for the shear/leach/ calcine facility and 2E-5 rem per year (1E-8 probability of fatal cancer) for the solvent extraction facility. The collective dose to the offsite population from the respective fuel stabilization facilities is estimated at 0.3 to 1 person-rem per year, resulting in less than one fatal cancer (would require from about 1000 to 3700 years of such exposure to reach a dose from which one fatal cancer might be inferred).

5.12.3 1992/1993 Planning Basis Alternative

Because the activities are similar, radiological consequences of routine operations for the 1992/1993 Planning Basis Alternative are considered to be the same as those for the Decentralization Alternative.

5.12.4 Regionalization Alternative

Radiological and nonradiological consequences relating to occupational and public health and safety for the Regionalization Alternative are presented in the following subsections.

5.12.4.1 Radiological Consequences. Because of the similarity of

activities, the radiological consequences of routine operations for the Regionalization Alternative Option A are considered to be the same as those for the Decentralization Alternative. The consequences to the public of options B and C are the same as described in the following section for the Centralization Maximum and Minimum options, respectively. Consequences to onsite workers would differ based on the processing and storage options for onsite fuel as in the decentralization alternative, as well as on the quantity of imported fuel to be received and placed into dry storage under each option. The consequences over the 40-year storage period range from 98 to 320 person-rem for option A, 700-920 person-rem for options B1 and B2, and 190-320 person-rem for option C. No fatal cancers would be expected as a result of implementing any of these options.

5.12.5 Centralization Alternative

Radiological and nonradiological consequences relating to occupational and public health and safety for the Centralization Alternative are presented in the following subsections.

5.12.5.1. Radiological consequences of air emissions from routine

operations in the Centralization Alternative include a maximum annual dose of 9E-9 rem to a potential onsite worker (4E-12 probability of fatal cancer) for any combination of wet or dry spent fuel storage facilities.

The collective

annual dose to SNF facility workers for a combination of wet and dry storage facilities is 2 person-rem per year for maintenance and operations. Loading the new facilities would require an additional 19-22 person-rem depending on the form of dry storage. For dry storage only, the dose from initial loading would be 9-12 person-rem, and there would be no dose from normal operations (Bergsman 1995). Shear/leach/calcine and solvent extraction activities would add 44 or 78 person-rem per year, respectively, and the receiving, canning, and technology development facilities would entail an additional 20 person-rem per year.

The dose from air emissions to an offsite resident at the highest exposure location is estimated as 2E-9 rem per year, and the corresponding probability of fatal cancer is 8E-13. The peak collective dose to the population within 80 kilometers (50 miles) is 7E-5 person-rem per year, which is predicted to result in less than one fatal cancer. These estimates do not include relocation of the expended core facility to Hanford, which is discussed in Appendix D to Volume 1 of this EIS. Assumptions used in the Appendix D calculations for consequences of locating an expended core facility at Hanford may differ from those used for other Hanford facilities.

5.13 Site Services

Implications of implementing the alternatives for interim storage of SNF on site services at the Hanford Site are discussed in the following subsections.

5.13.1 No Action Alternative

Implementing the No Action Alternative would require no significant additional consumption of material or energy; however, about 12,000 megawatt-hours per year are currently used for SNF management activities.

5.13.2 Decentralization Alternative

Incremental requirements for materials and energy in construction associated with the Decentralization Alternative are shown in Table 5.13-1. Annual consumption of energy during operations is similar to that used during construction for the water storage options (W and X), the total would be a small fraction of the present consumption rate. Annual consumption of energy during operations in the options where defense production fuel is stabilized is significantly greater; however it is still within the capacity of existing facilities.

Table 5-13-1. Materials and energy required for Decentralization suboptions.

Item	Option					
	W	X	Y	Z	P	Q
Concrete, thousand cubic meters/(cubic yards)	13 (17)	15 (20)	17 (23)	24 (32)	22 (29)	29 (38)
Carbon steel, thousand tonnes (tons)	2.4 (2.7)	2.8 (3.1)	3.3 (3.6)	4.5 (5.0)	3.9 (4.2)	5.1 (5.6)
Stainless steel, thousand tonnes (tons)	0.1 (0.1)	0.1 (0.1)	0	0	0.5 (0.6)	0.7 (0.8)
Copper, thousand tonnes (tons)	0	0	0	0	0.06 (0.07)	0.08 (0.09)
Lumber, thousand cubic meters (board feet)	1.2 (500)	1.4 (570)	1.6 (650)	2.2 (930)	2.0 (850)	2.6 (1100)
Asphalt, sand, and crushed rock, thousand cubic meters (thousand cubic yards)	0.6 (0.8)	0.7 (0.9)	0.8 (1.1)	1.2 (1.5)	1.1 (1.4)	1.4 (1.8)
Electricity						
Construction (MW-hrs)	2500	2900	3500	4800	4370	5700
Operations (MW-hrs/yr)	1600	1600	100	100	40,000a	127,000a
Diesel fuel, thousand cubic meters (thousand gallons)	0.5 (130)	0.6 (150)	0.7 (175)	0.9 (240)	0.8 (220)	1.1 (290)
Gasoline, thousand cubic meters (thousand gallons)	0.5 (130)	0.6 (150)	0.7 (175)	0.9 (240)	0.8 (220)	1.1 (290)
Construction Cost ($ Million)	265	280	350	310	580	835

a. Assumes operation of the process facility (28,000 or 115,000 MW-hrs/yr) concurrently with those facilities where SNF is currently stored (12,000 MW-hrs/yr, as in the No Action Alternative) for an interim period less than 4 years.

In the Decentralization Alternative, an extension of existing utilities to the project site area would likely be necessary. This would include water mains, electrical power lines, sewage facilities, telephone lines, etc. All of these utilities are available in the adjacent 200-East Area. In addition, an existing rail line might need to be upgraded for increased traffic, and construction of new spurs going to various proposed new facilities would likely be required. The project would be served by an 8-inch water main capable of delivering 7600 liters per minute (2000 gallons per minute). Facilities would be designed to preclude discharge of water except for sanitary waste.

5.13.3 1992/1993 Planning Basis Alternative

Energy requirements in the 1992/1993 Planning Basis Alternative would be essentially the same as those cited above for the Decentralization Alternative.

5.13.4 Regionalization Alternative

Material and energy requirements in the Regionalization Option A would be slightly less than those cited above for the Decentralization Alternative. Material and energy requirements in the Regionalization options would be similar to those cited above for the Decentralization Alternative, although the construction requirements would occur over most of the interim storage period. Incremental requirements for materials and energy in construction associated with the Regionalization options are shown in Tables 5.13-2 and

5.13-3. For the Regionalization options that involve fuel from other

locations being stored at the Hanford Site, the requirements shown are for fuel received from other locations and are in addition to those shown in **Table 5.13-1 for fuel already at the Hanford Site.** For the Regionalization option that has no fuel stored at the Hanford Site, the requirements shown are the total incremental requirements.

5.13.5 Centralization Alternative

Similar to the Decentralization Alternative, annual consumption of energy during operations is similar to that used during construction for the water storage options (W and X), and the total would be a small fraction of the present consumption rate. Annual consumption of energy during operations in the options where defense production fuel is stabilized is significantly greater; however it is still within the capacity of existing facilities. Materials and energy requirements for construction in the Centralization Alternatives are shown in Table 5.13-4. Similar to the Regionalization options, the Centralization Alternative that involves fuel from other locations being stored at the Hanford Site shows the requirements associated with storing the fuel received from other locations and are in addition to those shown for fuel already at the Hanford Site in Table 5.13-1. For the Centralization option that has no fuel stored at the Hanford Site, the requirements shown are the total incremental requirements.

In the Centralization Alternative where all SNF is brought to the Hanford Site, an extension of existing utilities to the project site area would be necessary. This would include water mains, electrical power lines, sewage facilities, telephone lines, etc. All of these utilities

Table 5-13-2. Materials and energy required for Regionalization A suboptions.

Item	Option					
	W	X	Y	Z	P	Q
Concrete, thousand cubic meters/(cubic yards)	9 (12)	9 (12)	16 (21)	19 (25)	22 (29)	29 (38)
Carbon steel, thousand tonnes (tons)	1.7 (1.9)	1.7 (1.9)	3.0 (3.4)	3.6 (4)	3.9 (4.2)	5.1 (5.6)
Stainless steel, thousand tonnes	0.1 (0.1)	0.1 (0.1)	0	0	0.5 (0.6)	0.7 (0.8)

(tons)						
Copper, thousand tonnes (tons)	0	0	0	0	0.06 (0.07)	0.08 (0.09)
Lumber, thousand cubic meters (board feet)	0.8 (350)	0.8 (350)	1.4 (600)	1.7 (700)	2.0 (850)	2.6 (1100)
Asphalt, sand, and crushed rock, thousand cubic meters (thousand cubic yards)	0.5 (0.6)	0.5 (0.6)	0.8 (1.0)	0.9 (1.2)	1.1 (1.4)	1.4 (1.8)
Electricity						
Construction (MW-hrs)	1800	1800	3200	3800	4370	5700
Operations (MW-hrs/yr)	1600	1600	100	100	40,000a	127,000a
Diesel fuel, thousands cubic meters (thousand gallons)	0.4 (100)	0.4 (100)	0.6 (160)	0.7 (190)	0.8 (220)	1.1 (290)
Gasoline, thousand cubic meters (thousand gallons)	0.4 (100)	0.4 (100)	0.6 (160)	0.7 (190)	0.8 (220)	1.1 (290)
Construction Cost ($ Million)	200	200	340	250	580	835

a. Assumes operation of the process facility (28,000 or 115,000 MW-Hrs/yr) concurrently with those facilities where SNF is currently stored (12,000 MW-Hrs/yr, as in the No Action Alternative) for an interim period less than 4 years.

Table 5-13-3. Materials and energy required for construction of Regionalization B and C options.

Item	Option		
	SNF Stored at the Hanford Site Without Naval SNF	SNF Stored at the Hanford Site With Naval SNF	No SNF Stored at the Hanford Site
Concrete, thousand cubic meters/(cubic yards)	54 (70)	115 (150)	18 (23)
Carbon steel, thousand tonnes (tons)	8.2 (9)	19.1 (21)	3.1 (3.4)
Stainless steel thousand tonnes (tons)	0.1 (0.1)	0.1 (0.1)	0.4 (.5)
Copper, thousand tonnes (tons)	0	0	0.05 (0.05)
Lumber, thousand cubic meters (board feet)	4.8 (2000)	10 (4200)	1.6 (660)
Asphalt, sand, and crushed rock, thousand cubic meters (thousand cubic yards)	2.5 (3.3)	5.4 (7.1)	0.8 (1.1)
Electricity			
Construction (MW-hrs)	16,000	30,000	3400
Operations (MW-hrs/yr)a	100-127,000	100-127,000	0-20,000
Diesel fuel, thousand cubic meters (thousand gallons)	1.9 (500)	4.2 (1100)	0.6 (170)
Gasoline, thousand cubic meters (thousand gallons)	1.9 (500)	4.2 (1100)	0.6 (170)
Construction Cost ($ Million)	765	1465	560

a. Minimum value represents requirements during the period after all fuel has been placed into dry storage, or has been shipped offsite. Maximum value represents requirements during the interim period (less than 4 years) while SNF is being processed and prepared for storage or shipment offsite, assuming concurrent operation of the process facility and the existing facilities where SNF is currently stored (as in the No Action Alternative). are available in the adjacent 200-East Area. In addition, an existing rail line might need to be upgraded for increased traffic and the construction of new spurs to various proposed new facilities would likely be required.

The following section describes the material requirements for operation of facilities in each SNF alternative and the corresponding quantities of waste generated by these activities. Table 5.14-1 lists the breakdown by alternative and suboption of the various types of waste generated by SNF management facilities.

Table 5-13-4. Materials and energy requirements for construction of Centralization options.

Item	No Fuel Stored at the Hanford Site	All Offsite Fuel Stored at the Hanford Site
Concrete, thousand cubic meters (cubic yards)	18 (23)	150 (200)
Carbon Steel, thousand tonnes (tons)	3.1 (3.4)	25 (27.5)
Stainless Steel, thousand tonnes (tons)	0.4 (0.5)	0.1 (0.1)
Copper, thousand tonnes (tons)	0.045 (0.05)	0
Lumber, thousand cubic meters (board feet)	1.6 (660)	13 (5600)
Asphalt, Sand, and Crushed Rock (thousand cubic meters (thousand cubic yards)	0.8 (1.1)	7.2 (9.5)
Electricity		
Construction (MW-hrs)	3400	40,000
Operations (MW-hrs/yr)a	0-20,000	100-127,000
Diesel fuel, thousand cubic meters (thousand gallons)	0.6 (170)	5.7 (1500)
Gasoline, thousand cubic meters (thousand gallons)	0.6 (170)	5.7 (1500)
Construction Cost ($ Million)	560	1950

a. Minimum value represents requirements during the period after all fuel has been placed into dry storage, or has been shipped offsite. Maximum value represents requirements during the interim period (less than 4 years) while SNF is being processed and prepared for storage or shipment offsite, assuming concurrent operation of the process facility and the existing facilities where SNF is currently stored (as in the No Action Alternative).

5.14 Materials and Waste Management

5.14.1 No Action Alternative

The No Action Alternative involves only fuel storage at existing facilities, and material requirements for the current configuration are minimal. The exception is make-up water for the 105-K fuel storage basins, which amounts to 2.8 million cubic meters per year.

The quantity of waste generated in the No Action Alternative is also relatively small because the only planned modifications to existing facilities are safety and security upgrades to the 105-K basins. About 530 cubic meters of low-level waste would result from containerization of SNF in 105-KE Basin, and small quantities of radioactive and mixed waste are generated at the 325 Building.

Table 5.14-1. Waste generation for spent nuclear fuel management alternatives.

Waste Type	No Action	Decentralization						Centralization	
		W	X	Y	Z	P	Q	Offsite	at Hanford a,b
Construction Waste (m3, total)	0	1500	1700	1700	2800	2600	3400	2000	15000
High-Level	0	0	0	0	0	0	57	14	0

Radioactive Waste (m3/y)									
Transuranic Waste (m3/y)	0	0	0	0	0	28	50	0	0
Low-Level Radioactive Waste (m3/y)[c]	95	41	50	0	0	280	420	140	68
Mixed Waste (Low-Level Radioactive and Hazardous, (m3/y)	0.96	0.23	0.23	0	0	2.0	2.0	1.0	0.28
Non-radioactive Hazardous Waste (m3/y)	2.3	1.1	1.1	0	0	2.8	2.8	1.4	1.1

a. These quantities are associated with new facilities that would be required for management of SNF shipped to Hanford from other sites. They represent incremental increases over those for facilities that are required to manage SNF currently at Hanford, which are discussed in the No-Action and Decentralization Alternatives.

b. A new ECF is not included in these totals; requirements for this facility are discussed in Volume 1, Appendix D.

c. Annual totals do not include containerization of defense production reactor SNF currently stored at the 105-K basins. This activity is expected to generate 530 cubic meters of low-level radioactive waste over a period of approximately 2 years.

Table 5.14-1. (contd)

Waste Type	Regionalization							
	AX	AY	AZ	AP	AQ	B1[a]	B2[a,b]	C
Construction Waste (m3, total)	900	1600	2100	2600	3400	5400	11,500	2000
High-Level Radioactive Waste (m3/y)	0	0	0	0	57	0	0	14
Transuranic Waste (m3/y)	0	0	0	28	50	0	0	0
Low-Level Radioactive Waste (m3/y)[c]	61	0	0	280	420	1.7	1.7	140
Mixed Waste (Low-Level Radioactive and Hazardous, (m3/y)	0.23	0	0	2.0	2.0	0.028	0.028	1.0
Non-radioactive Hazardous Waste (m3/y)	1.1	0	0	2.8	2.8	0.057	0.057	1.4

a. These quantities are associated with new facilities that would be required for management of SNF shipped to Hanford from other sites. They represent incremental increases over those for facilities that are required to manage SNF currently at Hanford, which are discussed in the No-Action and Decentralization Alternatives.

b. A new ECF is not included in these totals; requirements for this facility are discussed in Volume 1, Appendix D of this document.

c. Annual totals do not include containerization of defense production reactor SNF currently stored at the 105-K basins. This activity is expected to generate 530 cubic meters of low-level radioactive waste over a period of approximately 2 years.

5.14.2 Decentralization Alternative

Material requirements for the Decentralization Alternative depend on the suboption chosen. The suboptions involving wet storage of production reactor fuel (suboptions W and X) require make-up water for the storage basin at approximately 2300 cubic meters per year. Material requirements for dry storage of fuel (suboptions Y and Z) are minimal, and consist of decontamination chemicals in small quantities. Those suboptions including processing of production reactor fuel (suboptions P and Q, which would be combined with either Y or Z) require relatively large quantities of nitric acid (2000 - 4000 cubic meters per year) and other process chemicals in smaller quantities.

Construction waste generated for each of the suboptions depends on the size and number of facilities required. Dry storage of all fuel, including processing of production reactor fuel, would result in the largest quantity of construction waste, which is assumed to be nonradioactive, nonhazardous solids. Radioactive and hazardous waste from operations is also greater for the dry storage suboption with processing. Wet storage of production reactor fuel and dry storage of other onsite fuel results in the smallest quantity of both construction and operational hazardous waste.

5.14.3 1992/1993 Planning Basis Alternative

This alternative would be essentially the same as the Decentralization Alternative at Hanford.

5.14.4 Regionalization Alternative

Regionalization Alternative Option A would be essentially the same as the Decentralization Alternative at Hanford in terms of operational material requirements and waste generation because these originate largely from the storage pool or process facilities, depending on the suboption selected. The quantity of construction waste would be smaller because the dry storage capacity for nondefense production fuel would not be needed.

The Regionalization Alternative B options would require materials in similar quantities to the Decentralization Alternative, but would generate construction and operational wastes in greater quantities because of additional facilities that would be necessary to receive, package, and store imported SNF. Note that the waste quantities reported in Table 5.14-1 represent incremental increases for SNF facilities above those listed for the Decentralization Alternative.

The Regionalization Alternative Option C involves only stabilization of defense production fuel and packaging of all Hanford SNF for shipment offsite. It is identical to the Centralization Alternative minimum option as described in Section 5.14.5.

5.14.5 Centralization Alternative

The Centralization Alternative minimum option for offsite shipment of Hanford fuel requires construction of a stabilization and canning facility, which would produce annual quantities of construction and operational wastes similar to those for onsite combined wet and dry storage (suboptions W and X) in the Decentralization Alternative. However, these wastes would only be generated for the time required to stabilize and package fuel for offsite shipment (approximately 4 years).

Centralization at Hanford (maximum option) would include the same suboptions as Decentralization for SNF currently at Hanford, and the material requirements and waste generation would be identical. For SNF imported from other sites, additional dry storage capacity would be needed, and new additional facilities to package and examine the fuel would be constructed.

The estimates in Table 5.14-1 for Centralization at Hanford represent incremental increases for these additional facilities above those in the Decentralization Alternative. They do not incorporate the additional requirements of the Expended Core Facility, which are discussed in Volume 1, Appendix D of this document. Operational material requirements for the incremental dry storage capacity would be minimal, as would be the quantities of waste generated. Construction of the new facilities would generate nonhazardous solid waste in quantities greater than any of the other options, but operation of the additional facilities would produce relatively small quantities of radioactive and hazardous waste.

5.15 Facility Accidents

Implications of facility accidents associated with implementing the alternatives for SNF storage at Hanford are discussed in the following section. The method used to screen and select accidents for analysis is described, as are the procedures for evaluating the consequences of selected accidents, and the results of the analysis. Additional detail concerning specific accidents and parameters used in the analysis is provided in Attachment A, Facility Accidents.

5.15.1 Historical Accidents Involving SNF at Hanford

There are no known instances at Hanford where storage, handling, or processing of SNF has resulted in an accident that involved a significant release of radioactive or other hazardous materials to the environment or that resulted in detrimental exposure of workers or members of the public to hazardous materials.

5.15.2 Emergency Preparedness Planning at Hanford

Although the safety record for operations at Hanford and other DOE facilities is generally good, DOE-RL and all Hanford Site contractors have established Emergency Response Plans to prepare for and mitigate the consequences of potential emergencies on the Hanford Site (DOE 1992c). These plans were prepared in accordance with DOE Orders and other federal, state, and local regulations. The plans describe actions that will be taken to evaluate the severity of a potential emergency and the steps necessary to notify and coordinate the activities of other agencies having emergency response functions in the surrounding communities. They also specify levels at which the hazard to workers and the public are of sufficient concern that protective action should be taken. The Site holds regularly scheduled exercises to ensure that individuals with responsibilities in emergency planning are properly trained in the procedures that have been implemented to mitigate the consequences of potential accidents and other events.

5.15.3 Accident Screening and Selection for the EIS Analysis

The alternatives for SNF storage considered in this EIS necessitate evaluation of accidents at a variety of different types of facilities. In the No Action Alternative, the facilities consist of those where SNF is currently stored on the Hanford Site, or those where SNF will be stored at the time of the record of decision. All facilities considered in the No Action Alternative currently exist at the Hanford Site, and no construction of new facilities is assumed. For many of these facilities, storage of SNF is incidental to other activities that take place in the buildings. For the other alternatives (Decentralization, Regionalization, 1992/1993 Planning Basis, and Centralization), construction of new facilities dedicated solely to SNF management is assumed.

Accidents evaluated for existing facilities at Hanford consisted of maximum reasonably foreseeable accidents described in such previously published analyses as safety or NEPA documentation. The source documents for specific accidents evaluated in this section are referenced in the detailed accident descriptions in Attachment A. In the case of new facilities, hypothetical accidents were based on operation of similar facilities at

Hanford or other sites. Depending on the time at which the source document was prepared, the number and types of accidents considered for each facility would be somewhat variable. However, the screening process used in the relatively recent analyses considers a wide scope of accident initiators and scenarios, including industrial accidents (fires, explosions, overpressurization, loss of containment or confinement), criticality, operator error or injury, external hazards (surface vehicle or aircraft impact), waste management, natural phenomena (seismic events, wind, floods, volcanic activity), interactions with activities at adjacent facilities (construction, maintenance, operations), and common cause events (power failure). Older safety documents generally address these issues as well, although perhaps not with the same rigor as newer analyses. Transportation accidents are considered in a separate section of this appendix and are not discussed here.

Acts of terrorism are accounted for indirectly in the present analysis because the potential consequences of terrorist activities are used to determine security requirements for a given facility. Security measures are implemented to mitigate the impact, or reduce the probability, of high consequence events. Therefore, reasonably foreseeable scenarios for terrorist activities would entail risks that are similar to those for the types of accident initiators generally considered in the source documents that provide the basis for this analysis.

For the purposes of this EIS, accidents are ideally grouped into three categories based on their estimated frequencies as follows: abnormal events (frequency >10-3 per year), design basis accidents (frequencies <10-3 to 10-6 per year), and beyond design basis accidents (frequency <10-6 to 10-7 per year). Because the accident categories commonly used for development of safety documents encompass different probability ranges, the estimated frequencies (or frequency ranges) for Hanford facility accidents are reported as indicated in the source document without regard to the accident frequency categories established for use in the EIS. For accidents where only a range rather than a point estimate of frequency is available, the frequency of the accident is reported as being less than the highest frequency that defines the range. In alternatives that consider SNF imported from other sites (such as other DOE facilities or U.S. and foreign research reactors), frequencies for specific accidents have been adjusted to account for increased fuel handling at receiving, canning, and storage facilities.

Accident frequencies as reported in safety documents (Safety Analysis Reports and related analyses) typically represent the overall probability of the accident, including the probability of the initiating event combined with the frequency of any contributing events required for an environmental release to occur. The contributing events may include equipment or barrier failures, or failures of other mitigating systems designed to prevent accidental releases. In general, the safety documents do not evaluate the consequences of events with expected frequencies of <10-6 per year because such accidents are not considered reasonably foreseeable; therefore, accidents in the beyond design basis category are generally not evaluated for this analysis. Evaluation of aircraft traffic at the Richland and Pasco, Washington airports determined that impacts of commercial or military aircraft were less than 1x10-7 for a facility in the Hanford 300 Area, which is at highest risk because of its location (PNL 1992a). Therefore, aircraft accidents are not considered further in this analysis as initiators for accidents at Hanford SNF management facilities.

As noted previously, the safety documents for SNF facilities generally considered a broad range of accidents; however, only the consequences of the maximum reasonably foreseeable accidents for each facility in a given alternative were evaluated for this document. Of the existing facilities assessed in the No Action Alternative, most are multipurpose facilities with diverse missions such as research or process development. These facilities typically contain relatively small quantities of SNF relative to the 105-K basins, where the bulk of Hanford's existing SNF is stored. The accidents evaluated in the source documents for multipurpose facilities may therefore reflect activities other than SNF storage or handling. The risks for such accidents are reported in this EIS for completeness, although in some cases, neither the frequency nor the consequences associated with the accident depend on the presence of SNF in the facility.

5.15.4 Method for Accident Consequence Analysis

In the No Action Alternative, accident consequence analyses utilized release estimates as presented in the source document for a given existing facility. For new facilities, release estimates were based on historical operation of similar facilities at Hanford. These estimates were also assumed to represent typical accidental releases in alternatives that consider storage of fuel from offsite locations, such as other DOE facilities or U.S. and foreign research reactors. Accidents evaluated for the research reactor fuels indicate that releases for such specialized fuels would be comparable to those included in this analysis (DOE 1993b; Hale and Reutzel 1993). The assumptions used to determine radionuclide releases are included in Attachment A.

Because most source documents (other than the more recent Safety Analysis Reports) do not evaluate hazardous materials other than radionuclides, a different approach was used for accidents involving nonradioactive materials. The hazardous material inventories for each facility were used to estimate releases based on the physical state of each compound as described in Attachment A. Specific initiators and accident scenarios were generally not postulated for nonradioactive materials; therefore, frequencies were not estimated for hazardous chemical accidents.

The downwind concentrations for materials released in accidents were then calculated at receptor locations as defined for the EIS. The receptors included a worker who is onsite but outside the facility where the accident takes place, a member of the public who is temporarily at the nearest access location (such as a road that crosses the site or at the site boundary), and the maximally exposed offsite resident. Collective dose to the population within 80 kilometers (50 miles) was also calculated for radionuclide releases. Individual dispersion calculations were performed using 95 percent atmospheric conditions (those resulting in air concentrations that would not be exceeded more than 5 percent of the time). Dose to the population was calculated using both 50 percent and 95 percent atmospheric dispersion parameters. Dispersion calculations were performed using the GENII computer code (Napier et al. 1988) for radionuclide releases and the EPIcode (Homann 1988) for nonradioactive compounds.

The radiation dose to each receptor evaluated for the EIS was recalculated for the specific conditions and release location as appropriate to each alternative using the GENII computer code. Doses were calculated as the effective dose equivalent using standard assumptions for the Hanford Site as summarized in Schreckhise et al. (1993). Health effects were also estimated as probability of fatal cancer based on recommendations of the International Commission on Radiological Protection in its Publication 60 (ICRP 1991). The accident doses were recalculated for this analysis using a consistent, reasonably conservative set of methods and assumptions and to include the complete set of receptors that are to be evaluated in the EIS. This was necessary because the methods used in the source documents were not necessarily consistent and in some cases were outdated. For this reason, the doses developed for this analysis may differ from those reported in the source documents that describe the accidents; however, they should be viewed as a screening analysis for the purposes of the EIS and are not intended to replace or invalidate the previous results.

Individual doses were based on exposure of the receptor during the entire release, except where the release time was sufficiently long that such an assumption is unrealistic. For releases that were expected to last more than a few hours, the exposure duration for onsite workers and members of the public at accessible onsite locations was limited to 2 hours, corresponding to the maximum time required to evacuate the Hanford Site in the event of an accident. Offsite residents were assumed to be exposed during the entire release, regardless of the accident duration. Exposure via inhalation and external pathways (groundshine and submersion in the plume) were considered for workers and the nearest public access receptors; ingestion of contaminated food was evaluated only for offsite residents. Because protective action guidelines specify mitigative actions to prevent consumption of contaminated food, the ingestion dose to offsite individuals and populations is reported separately from the other exposure routes. Reduced exposure to the plume or to contaminated ground surface as a result of early evacuation of offsite populations is not assumed for the purposes of this analysis, although such actions would also be mandated if the projected dose from an accident exceeded the protective action guidelines. Because the circumstances and consequences postulated for workers at the scene of an accident are so speculative, they serve no useful purpose in the decision-making process. As a consequence, discussion of impacts on "close-in" workers are not brought forward into the text of this Appendix. Consequences in terms of the "close-in" workers for one scenario in each accident may be found in Attachment A.

5.15.5 Radiological Accident Analysis

5.15.5.1 No Action Alternative. The No Action Alternative consists of

fuel storage at existing Hanford facilities, including the 100-K wet storage basins; T Plant, and a low-level burial ground in the 200-West Area; the 308, 324, 325, and 327 buildings in the 300 Area; and the Fast Flux Test Facility (FFTF) in the 400 Area. Of these facilities, only the 100-K storage basins and the FFTF fuel storage facility are primarily devoted to SNF storage; the others are all multipurpose facilities that house a variety of activities in addition to storing relatively small quantities of SNF. The consequences and risks of accidents associated with these facilities are described in Tables 5.15-1 through 5.15-5.

The maximum reasonably foreseeable accident for multipurpose facilities is an earthquake scenario at the 324 Building, which releases non-SNF related radioactive material that has accumulated in a hot cell (Table 5.15-1 through **Table 5.15-5).** The contributions of other activities at the facility, including SNF storage, are estimated to be relatively minor. The maximum reasonably foreseeable accident directly involving SNF management is a fire at a fuel storage facility adjacent to FFTF. Several of the accident scenarios evaluated for this alternative involve initiators that could affect more than one facility (e.g., earthquakes); however, the combined consequences of releases from potentially affected facilities have not been evaluated for a common receptor.

5.15.5.2 Decentralization Alternative. The Decentralization

Alternative involves several options for construction of new facilities at Hanford. One option includes a combination of new wet storage for defense production reactor fuel currently stored at the 105-K basins and new dry storage for fuel that is currently at other locations. Alternative options are included for processing of production reactor fuel prior to dry storage. The consequences of accidents at the new facilities are based on previously evaluated accidents for similar installations, adapted for the conditions and location of these facilities as assumed in this EIS.

The maximum reasonably foreseeable accident for the new facilities is a severe cask impact followed by a fire at a dry storage facility (Tables 5.15-1 through 5.15-5). The risk from a cask drop while loading fuel at a wet storage facility is similar for most receptors, although this scenario is conservative for a new facility as discussed in Attachment A.

5.15.5.3 1992/1993 Planning Basis Alternative. Accidents and

consequences would be essentially the same as for the Decentralization Alternative.

5.15.5.4 Regionalization Alternative. The consequences of the

regionalization alternatives are similar to those of other action alternatives because they only differ in the quantity of imported fuel placed into dry storage at the site. The types of facilities and activities involved are generally the same as those considered for the decentralization and centralization alternatives. Point estimates of risk for some accidents differ from those of corresponding

Table 5.15-1. Radiological accidents, individual worker probability of latent cancer fatality.

Accident Description	Attribute	No Action	Decentralization	1992/1993 Planning Basis	Regionalization A, B	Centralization at Hanford	Regionalization or Centralization - Other Site
SNF facilities:							
Wet storage fuel cask drop	Consequences	1.4E-03	3.5E-04	3.5E-04	3.5E-04	3.5E-04	NAa
	Annual Frequency	<1E-04	<1E-04	<1E-04	<1E-04	<1E-04	NA
	Point Estimate of Risk	<1.4E-07	<3.5E-08	<3.5E-08	<3.5E-08	<3.5E-08	NA
FFTF liquid metal fire in fuel storage	Consequences	2.4E-07	NA	NA	NA	NA	NA
	Annual	<1E-04	NA	NA			

	Frequency				NA	NA	NA	
	Point Estimate of Risk	<2.9E-11	NA	NA	NA	NA	NA	
Multi-Purpose Facilities:								
324 Building Seismic evente	Consequences	(b)	NA	NA	NA	NA	NA	
	Annual Frequency	4E-04	NA	NA	NA	NA	NA	
	Point Estimate of Risk	(b)	NA	NA	NA	NA	NA	
325 Building Seismic event	Consequences	1.0E-01	NA	NA	NA	NA	NA	
	Annual Frequency	2E-04	NA	NA	NA	NA	NA	
	Point Estimate of Risk	2.0E-05	NA	NA	NA	NA	NA	
308 Building Fuel transfer accident	Consequences	5.2E-06	NA	NA	5.2E-06	NA	NA	
	Annual Frequency	<1E-02	NA	NA	<1E-02	NA	NA	
	Point Estimate of Risk	<5.2E-08	NA	NA	<5.2E-08	NA	NA	

Table 5.15-1. (contd)

Accident Description	Attribute	No Action	Decentralization	1992/1993 Planning Basis	Regionalization A	B	Centralization at Hanford	Regionalization or Centralization - Other Site
New dry storage - cask impact & fire	Consequences	NAa	9.4E-02	9.4E-02	9.4E-02	9.4E-02	9.4E-02	9.4E-02
	Annual Frequency	NA	6E-06	6E-06	6E-06	7E-06	8E-06	5E-06
	Point Estimate of Risk	NA	5.6E-07	5.6E-07	5.6E-07	6.6E-07	7.5E-07	4.7E-07
New SNF process - U metal fire	Consequences	NA	8.3E-08	8.3E-08	8.3E-08	8.3E-08	8.3E-08	8.3E-08
	Annual Frequency	NA	<1.0E-04	<1.0E-04	<1.0E-04	<1.0E-04	<1.0E-04	<1.0E-04
	Point Estimate of Risk	NA	<8.3E-12	<8.3E-12	<8.3E-12	<8.3E-12	<8.3E-12	<8.3E-12
New ECF	Consequences	NA	NA	NA	NA	(c)	(c)	NA
	Annual Frequency	NA	NA	NA	NA	-d	-	NA
	Point Estimate of Risk	NA	NA	NA	NA	-	-	NA

a. NA = Not applicable.

b. The dose from this scenario (1.1E + 03) rem is sufficiently high that application of a fatal cancer risk factor is inappropriate.
c. See Appendix D for consequences of accidents at this facility.
d. Dash indicates that the information was not available.
e. The consequences associated with this accident are a result of existing contamination in the 324 Building hot cells, and neither its likelihood nor its severity depend on the presence of spent nuclear fuel at the facility. The actual contribution of spent nuclear fuel to releases from the accident is assumed to be negligible compared with that of other sources.

Table 5.15-2. Radiological accidents, general population - 80 km latent cancer fatalities, 95% meteorology.

Accident Description	Attribute	No Action	Decentralization	1992/1993 Planning Basis	Regionalization A, B	Centralization at Hanford	Regionalization or Centralization - Other Site
SNF Facilities:							
Wet Storage Fuel Cask Drop	Consequences	6.9E+00	3.0E+00	3.0E+00	3.0E+00	3.0E+00	NAa
	Annual Frequency	<1.0E-04	<1.0E-04	<1.0E-04	<1.0E-04	<1.0E-04	NA
	Point Estimate of Risk	<6.9E-04	<3.0E-04	<3.0E-04	<3.0E-04	<3.0E-04	NA
FFTF Liquid Metal Fire in Fuel Storage	Consequences	3.2E+01	NA	NA	NA	NA	NA
	Annual Frequency	<1.0E-04	NA	NA	NA	NA	NA
	Point Estimate of Risk	<3.2E-03	NA	NA	NA	NA	NA
Multipurpose Facilities:							
324 Building Seismic Evente	Consequences	9.7E+02	NA	NA	NA	NA	NA
	Annual Frequency	4E-04	NA	NA	NA	NA	NA
	Point Estimate of Risk	3.9E-01	NA	NA	NA	NA	NA
325 Building Seismic Event	Consequences	2.0E+00	NA	NA	NA	NA	NA
	Annual Frequency	2E-04	NA	NA	NA	NA	NA
	Point Estimate of Risk	4.0E-04	NA	NA	NA	NA	NA
308 Building Fuel Transfer Accident	Consequences	NEb	NA	NA	NE	NA	NA
	Annual Frequency	<1.0E-02	NA	NA	-c	NA	NA
	Point Estimate of Risk	-	NA	NA	-	NA	NA

Table 5.15-2. (contd)

Accident Description	Attribute	No Action	Decentralization	1992/1993 Planning Basis	Regionalization A	Regionalization B	Centralization at Hanford	or Centralization - Other Site
New dry storage - cask impact & fire	Consequences	NA	8.1E+01	8.1E+01	8.1E+01	8.1E+01	8.1E+01	8.1E+01
	Annual Frequency	NA	6E-06	6E-06	6E-06	7E-06	8E-06	5E-06
	Point Estimate of Risk	NA	4.9E-04	4.9E-04	4.9E-04	5.7E-04	6.5E-04	4.1E-04
New SNF process - U metal fire	Consequences	NA	6.4E-02	6.4E-02	6.4E-02	-c	6.4E-02	6.4E-02
	Annual Frequency	NA	<1.0E-04	<1.0E-04	<1.0E-04	-	<1.0E-04	<1.0E-04
	Point Estimate of Risk	NA	<6.4E-06	<6.4E-06	<6.4E-06	-	<6.4E-06	<6.4E-06
New ECF	Consequences	NA	NA	NA	NA	-	(d)	NA
	Annual Frequency	NA	NA	NA	NA	-	-	NA
	Point Estimate of Risk	NA	NA	NA	NA	-	-	NA

a. NA = Not applicable.
b. NE = Collective dose not evaluated for this scenario.
c. Dash indicates that the information was not available.
d. See Appendix D for consequences.
e. The consequences associated with this accident are a result of existing contamination in the 324 Building hot cells, and neither its likelihood nor its severity depend on the presence of SNF at the facility. The actual contribution of SNF to releases from the accident is assumed to be negligible compared with that of other sources.

Table 5.15-3. Radiological accidents, general population - 80 km latent cancer fatalities, 50% meteorology.

Accident Description	Attribute	No Action	Decentralization	199219/93 Planning Basis	Regionalization A, B	Centralization at Hanford	or Centralization - Other Site
SNF Facilities:							
Wet storage - fuel cask drop	Consequences	4.0E-01	1.9E-01	1.9E-01	1.9E-01	1.9E-01	NAa
	Annual Frequency	<1.0E-04	<1.0E-04	<1.0E-04	<1.0E-04	<1.0E-04	NA
	Point Estimate of Risk	<4.0E-05	<1.9E-05	<1.9E-05	<1.9E-05	<1.9E-05	NA
FFTF liquid metal fire in fuel storage	Consequences	3.8E+00	NA	NA	NA	NA	NA
	Annual Frequency	<1.0E-04	NA	NA	NA	NA	NA
	Point Estimate	<3.8E-04	NA	NA			

```
NA                 NA                NA
             of Risk
Multipurpose Facilities:
324          Consequences           1.0E+02              NA                     NA                NA
NA               NA
Building
Seismic
Evente
             Annual                 4E-04                NA                     NA
NA                 NA                NA
             Frequency
             Point Estimate         4.0E-02              NA                     NA
NA                 NA                NA
             of Risk
325          Consequences           2.3E-01              NA                     NA
NA                 NA                NA
Building
Seismic
Event
             Annual                 2E-04                NA                     NA
NA                 NA                NA
             Frequency
             Point Estimate         4.6E-05              NA                     NA
NA                 NA                NA
             of Risk
308          Consequences           NEb                  NA                     NA
NE                 NA                NA
Building     Annual                 <1.0E-02             NA                     NA                -
c                NA                NA
fuel         Frequency              -                    NA                     NA                -
NA               NA
transfer     Point Estimate
accident     of Risk
```

Table 5.15-3. (contd)

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Accident     Attribute              No Action            Decentralization       1992/1993
Regionalization          Centralization       Regionalization
Description                                                                     Planning
at Hanford          or Centralization
                                                                                Basis
- Other Site
                                                                                                  A
B

New dry      Consequences           NA                   4.0                    4.0
4.0              4.0    4.0                  4.0
storage -
cask impact
& fire
             Annual                 NA                   6E-06                  6E-06
6E-06            7E-06  8E-06                5E-06
             Frequency
             Point Estimate         NA                   2.4E-05                2.4E-05
2.4E-05          2.8E-  3.2E-05              2.0E-05
             of Risk
05
New SNF      Consequences           NA                   4.6E-03                4.6E-03
4.6E-03          4.6E-  4.6E-03              4.6E-03
process -
03
U metal
fire
             Annual                 NA                   <1.0E-04               <1.0E-04
<1.0E-04         <1.0E- <1.0E-04             <1.0E-04
             Frequency
04
             Point Estimate         NA                   <4.6E-07               <4.6E-07
<4.6E-07         <4.6E- <4.6E-07             <4.6E-07
             of Risk
07
New ECF      Consequences           NA                   NA                     NA
NA               (d)    (d)                  NA
             Annual                 NA                   NA                     NA
NA               -      -                    NA
             Frequency
             Point Estimate         NA                   NA                     NA
NA               -      -                    NA
             of Risk
```

a. NA = Not applicable.
b. NE = Collective dose not evaluated for this scenario.

c. Dash indicates that the information was not available.
d. See Appendix D for consequences of accidents at this facility.
e. The consequences associated with this accident are a result of existing contamination in the 324 Building hot cells, and neither its likelihood nor its severity depend on the presence of SNF at the facility. The actual contribution of SNF to releases from the accident is assumed to be negligible compared with that of other sources.

Table 5.15-4. Radiological accidents, nearest public access - individual probability of latent cancer fatality.

Accident Description	Attribute	No Action	Decentralization	1992/1993 Planning Basis	Regionalization A, B - Other Site	Centralization at Hanford	Regionalization or Centralization
SNF Facilities:							
Wet storage fuel cask drop	Consequences	1.3E-03	3.1E-05	3.1E-05	3.1E-05	3.1E-05	NAa
	Annual Frequency	<1E-04	<1E-04	<1E-04	<1E-04	<1E-04	NA
	Point Estimate of Risk	<1.3E-07	<3.1E-09	<3.1E-09	<3.1E-09	<3.1E-09	NA
FFTF liquid metal fire in fuel storage	Consequences	1.2E-07	NA	NA	NA	NA	NA
	Annual Frequency	<1E-04	NA	NA	NA	NA	NA
	Point Estimate of Risk	<1.2E-11	NA	NA	NA	NA	NA
Multipurpose facilities:							
324 Building Seismic Event[d]	Consequences	1.9E-01	NA	NA	NA	NA	NA
	Annual Frequency	4E-04	NA	NA	NA	NA	NA
	Point Estimate of Risk	7.6E-05	NA	NA	NA	NA	NA
325 Building seismic event	Consequences	6.3E-03	NA	NA	NA	NA	NA
	Annual Frequency	2E-04	NA	NA	NA	NA	NA
	Point Estimate of Risk	1.3E-06	NA	NA	NA	NA	NA
308 Building fuel transfer accident	Consequences	4.3E-07	NA	NA	4.3E-07	NA	NA
	Annual Frequency	<1E-02	NA	NA	<1E-02	NA	NA
	Point Estimate of	<4.3E-09	NA	NA	<4.3E-09	NA	NA

Table 5.15-4. (contd)

Accident Description	Risk Attribute	No Action	Decentralization	1992/1993 Planning Basis	Regionalization A	Regionalization B	Centralization at Hanford	Centralization - Other Site
New dry storage - cask impact and fire	Consequences	NA	3.8E-05	3.8E-05	3.8E-05	3.8E-05	3.8E-05	3.8E-05
	Annual Frequency	NA	6E-06	6E-06	6E-06	7E-06	8E-06	5E-06
	Point Estimate of Risk	NA	2.3E-10	2.3E-10	2.3E-10	2.7E-10	3.0E-10	1.9E-10
New SNF process - U metal fire	Consequences	NA	2.2E-08	2.2E-08	2.2E-08	2.2E-08	2.2E-08	2.2E-08
	Annual Frequency	NA	<1.0E-04	<1.0E-04	<1.0E-04	<1.0E-04	<1.0E-04	<1.0E-04
	Point Estimate of Risk	NA	<2.2E-12	<2.2E-12	<2.2E-12	<2.2E-12	<2.2E-12	<2.2E-12
New ECF	Consequences	NA	NA	NA	NA	(c)	(c)	NA
	Annual Frequency	NA	NA	NA	NA	-	-	NA
	Point Estimate of Risk	NA	NA	NA	NA	-	-	NA

a. NA = Not applicable.
b. See Appendix D for consequences of accidents at this facility.
c. The consequences associated with this accident are a result of existing contamination in the 324 Building hot cells, and neither its likelihood nor its severity depend on the presence of SNF at the facility. The actual contribution of SNF to releases from the accident is assumed to be negligible compared with that of other sources.

Table 5.15-5. Maximum exposed offsite individual - probability of latent cancer fatality.

Accident Description	Risk Attribute	No Action	Decentralization	1992/1993 Planning Basis	Regionalization A, B	Centralization at Hanford	Centralization - Other Site
SNF Facilities:							
Wet storage fuel cask drop	Consequences	2.5E-04a	1.8E-04	1.8E-04	1.8E-04	1.8E-04	NAb
	Annual Frequency	<1E-04	<1E-04	<1E-04	<1E-04	<1E-04	NA
	Point Estimate of Risk	<2.5E-08	<1.8E-08	<1.8E-08	<1.8E-08	<1.8E-08	NA
FFTF liquid metal Fire in fuel storage	Consequences	2.5E-04a	NA	NA	NA	NA	NA
	Annual	<1E-04	NA	NA			

	Frequency				NA	NA	NA
	Point Estimate of Risk	2.5E-08	NA	NA	NA	NA	NA
Multipurpose Facilities:							
324 Building Seismic Eventd	Consequences	2.5E-04a	NA	NA	NA	NA	NA
	Annual Frequency	4E-04	NA	NA	NA	NA	NA
	Point Estimate of Risk	1.0E-07	NA	NA	NA	NA	NA
325 Building Seismic Event	Consequences	2.5E-04a	NA	NA	NA	NA	NA
	Annual Frequency	2E-04	NA	NA	NA	NA	NA
	Point Estimate of Risk	5.0E-08	NA	NA	NA	NA	NA
308 Building fuel transfer accident	Consequences	4.3E-08	NA	NA	4.3E-08	NA	NA
	Annual Frequency	<1E-02	NA	NA	<1E-02	NA	NA
	Point Estimate of Risk	4.3E-10	NA	NA	4.3E-10	NA	NA

Table 5.15-5. (contd)

Accident Description	Attribute	No Action	Decentralization	1992/1993 Planning Basis	Regionalization A	Regionalization B	Centralization at Hanford	Regionalization or Centralization - Other Site
New dry storage - cask impact & fire	Consequences	NA	2.5E-04	2.5E-04	2.5E-04	2.5E-04	2.5E-04	2.5E-04
	Annual Frequency	NA	6E-06	6E-06	6E-06	7E-06	8E-06	5E-06
	Point Estimate of Risk	NA	1.5E-09	1.5E-09	1.5E-09	1.8E-09	2.0E-09	1.2E-09
New SNF process - U metal fire	Consequences	NA	3.4E-06	3.4E-06	3.4E-06	3.4E-06	3.4E-06	3.4E-06
	Annual Frequency	NA	<1.0E-04	<1.0E-04	<1.0E-04	<1.0E-04	<1.0E-04	<1.0E-04
	Point Estimate of Risk	NA	<3.4E-10	<3.4E-10	<3.4E-10	<3.4E-10	<3.4E-10	<3.4E-10
New ECF	Consequences	NA	NA	NA	NA	(c)	(c)	NA
	Annual Frequency	NA	NA	NA	NA	-	-	NA

Point - Estimate of Risk	NA	NA	NA	NA	-	NA

a. The offsite dose from this accident is assumed to be limited to 0.5 rem by application of protective action guidelines. Potential dose without protective action is 1.4 rem for 105-K Basin Cask drop, 5400 rem for 324 Building seismic event, 16 rem for 325 Building seismic event, and 5 rem for FFTF liquid metal fire.
b. NA = Not applicable.
c. See Appendix D for consequences of accidents at this facility.
d. The consequences associated with this accident are a result of existing contamination in the 324 Building hot cells, and neither its likelihood nor its severity depend on the presence of SNF at the facility. The actual contribution of SNF to releases from the accident is assumed to be negligible compared with that of other sources.

accidents in the other alternatives because the frequencies were adjusted to account for the quantity of fuel handled in each option (See Tables 5.15-1 through 5.15-5). Under subalternatives A and B, the types of accidents and their consequences would be the same as those for the decentralization alternative. However, the frequencies (and therefore the risks), would differ in some cases because of the volume of imported fuel that would be placed into dry storage. For subalternative C, all fuel currently at Hanford would be transported to another site, and the risks would be identical to those in the centralization minimum alternative.

5.15.5.5 Centralization Alternative. The Centralization Alternative

consists of two options at Hanford: a minimum option in which all DOE spent fuel at Hanford is transported offsite to another location for interim storage, and a maximum option that would result in storage of all DOE spent fuel at Hanford. Accident scenarios for the minimum option would include those discussed under the No Action Alternative prior to shipment of the fuel offsite. In addition, defense reactor fuel would be processed and repackaged in a new facility prior to shipment. The risks associated with this new facility are expected to be similar to the processing facility discussed under the Decentralization Alternative. The cask impact accident at a dry storage facility has been included in this option to account for handling of fuel prior to shipment from Hanford.

The maximum option contains suboptions for wet or dry fuel storage with processing similar to those for the Decentralization Alternative, and the consequences are expected to be essentially the same as those described previously. The frequency of the cask impact at a dry storage facility has been increased to account for additional fuel that would be handled at Hanford under this option. The only other installation that would be included in this option is the Expended Core Facility (ECF), which would be relocated from INEL. The consequences of accidents at this facility are discussed in Volume 1, Appendix D of this EIS, and are not described here. Note that the accident analysis for the ECF in Appendix D incorporates different assumptions than those used for other Hanford facilities in this section, and the two sets of results are not directly comparable. The consequences of ECF accidents at Hanford using assumptions consistent with those in this section would be higher than those reported in Appendix D.

5.15.6 Secondary Impacts of Radiological Accidents

Secondary impacts of radiological accidents have been evaluated qualitatively for this analysis. Accidents that resulted in doses to the maximally exposed offsite resident of less than 100 millirem were considered to have little or no secondary impact because the levels of environmental contamination in these cases would be relatively small. Accidents that exceed this level may have secondary impacts with severity depending on the expected levels of environmental contamination. Although the levels of environmental contamination were not assessed quantitatively for this analysis, the offsite individual dose provides a measure of the air concentration and radionuclide deposition at the receptor location and can be used as a semi-quantitative estimate of the level of environmental contamination from a given accident. The estimated secondary consequences of maximum reasonably foreseeable SNF facility accidents are presented in Table 5.15-6.

5.15.7 Nonradiological Accident Analysis

For purposes of the EIS, a worst case accident scenario was developed for each existing and planned facility. The details of the nonradiological accident scenario are presented in Attachment A, and the information is summarized in this section. The accident assumes that a chemical spill occurs within a building and is followed by an environmental release from the normal exhaust system. It is assumed that the building remains intact but containment measures fail, allowing releases occur through the ventilation system. It is assumed that all, or a portion of, the entire inventory of toxic chemicals stored in each building is spilled. The environmental releases are modeled, and the hypothetical concentrations at three receptor locations are compared to toxicological limits.

Several chemical inventory and chemical emissions lists are provided by alternative and facility (Bergsman 1995). Effects to onsite workers, the nearest point of public access, and the public at the nearest offsite residence were estimated using the computer model EPIcode (DOE 1993b). Results from the EPIcode model were compared to available Emergency Response Planning Guideline (ERPG) values, Immediately Dangerous to Life and Health (IDLH) values, and Threshold Limit Values/Time Weighted Averages (TLV/TWA). In the absence of these values, toxicological data for similar health endpoints, from the Registry of Toxic Effects for Chemical Substances (RTEC) are used.

The results of the accident scenario for each alternative are presented in **Table 5.15-8.** As a general statement, in the event of an accident, the existing 105-KE and 105-KW facilities and the proposed new wet storage facility present the predominant risk for chemical exposure.

Under the No Action Alternative there is a potential for irreversible health effects to occur in the 308, 324, 325 A and B buildings, while nitric acid is a potential odor and irritation problem from both of the proposed fuel stabilization alternatives.

5.15.7.1 No Action Alternative. A baseline of chemicals kept in spent

nuclear storage facilities was developed from chemical inventories for these facilities compiled to comply with the Emergency Planning and Community Right-To-Know Act (EPCRA). The existing storage facilities include 105-KE, 105-KW, PUREX (202A), T-Plant (221T), 2736-ZB Building, 200-West low-level burial grounds, FFTF 403 Building, 308 Building, 324 Building, 325 A&B Building, and 327 Building. The Emergency Planning and Community Right-To-Know Act (EPCRA) lists used are from 1992.

Because most facilities have various missions, the need to have a supply of chemicals at these facilities may not be related to the storage of SNFs. However for purposes of the EIS, the assumption is made that the existing inventories represents the anticipated amounts and types of chemicals which may be needed in the future.

The results of the accident scenario under conditions of the No Action Alternative are presented in Table 5.15-7.

5.15.7.2 Decentralization Alternative. The Decentralization Alternative

involves construction of several new facilities at Hanford, including new dry storage for spent fuel, or a combination of new wet and dry storage. Options are also included for several types of fuel processing prior to storage. The consequences of new facilities are based on previously evaluated accidents for similar installations, adapted for the conditions and locations of these facilities as assumed in this EIS.

The baseline chemical inventory for the proposed facilities is primarily derived from the facility costs section in the engineering design data (Bergsman 1995). However, the wet storage facility uses the 105-KE Basin as a surrogate for a baseline chemical inventory because the facility cost section lists only two chemicals, sodium hydroxide and sulfuric acid.

Table 5.15-6. Assessment of secondary impacts of accidents for the No-Action Alternative.

	Environmental or Social Factor							
Accident Description	Biotic Resources	Water Resources	Economic Impacts	National Defense	Environmental Contamination	Endangered Species	Land Use	Treaty Rights, Cultural

Resources,

Native Cultures

Accidents with frequencies y10-3 per year								
308 Building (fuel handling accident)	a	a	a	a	a	a	a	a
Accidents with frequencies <10-3 per year								
324 Building (seismic event)	Potential local effects on individ- uals of some species	Potential temporary closure of Hanford Reach of Columbia River to boat traffic, restriction of water use locally (Richland, Pasco)	Possible loss of crops, cost incurred for clean-up	None antici- pated	May be extensive in vicinity of facility and adjacent offsite areas	None anticipated	Restriction on use of adjacent land for agriculture, and of Columbia River islands, pending radiological survey	Possible temporary restrictions on access to traditional fishing sites
325 Building (seismic event)	b	b	b	b	b	b	b	b
FFTF fuel storage (liquid metal fire)	b	b	b	b	b	b	b	b
105-K wet storage (cask drop)	b	b	b	b	b	b	b	b
200-W burial ground (cask impact & fire)	b	b	b	b	b	b	b	b
327 Building (hot cell fire)	b	b	b	b	b	b	b	b
T-plant (fuel damage)	a	a	a	a	a	a	a	a

a. Consequences of this accident would be limited to very local onsite impact only, if any.
b. Consequences of this accident would be similar in nature to those of the 324 building or new dry storage facility (worst case) accidents; however they would be less severe because offsite concentrations would be lower by at least two orders of magnitude.

The results of the accident scenario under conditions of the Decentralization Alternative are presented in Table 5.15-8.

5.15.7.3 1992/93 Planning Basis Alternative. Accidents and consequences

would be essentially the same as for the Decentralization Alternative.

5.15.7.4 Regionalization Alternative. Except for Regionalization Option

C, which would be essentially the same as the Centralization Alternative minimum case, accidents and consequences for options A, B1, and B2 would be essentially the same as for the Decentralization Alternative. The quantity of nondefense fuels placed into dry storage would not affect the potential for releases of hazardous chemicals because no such materials are present in the dry storage facilities.

5.15.7.5 Centralization Onsite Alternative. The Centralization Onsite

Alternative consists of consolidating all spent fuel at the Hanford site. Options are available for wet or dry fuel storage with processing similar to those for the Decentralization Alternative. The consequences are expected to be essentially the same as those described for the first 5 years of the No Action Alternative, and then they are the same as those described for the Decentralization Alternative.

The results of the accident scenario under conditions of the No Action and Decentralization Alternatives are presented in Table 5.15-8.

5.15.7.6 Centralization Offsite Alternative. The Centralization Offsite

Alternative consists of transporting all DOE SNF at Hanford offsite to another location for interim storage. Fuel would be stabilized prior to shipment in a fuel drying and passivation facility. Therefore the impacts from this alternative are the same as those for the No Action Alternative for the first 5 years, and then they are the same as those described for the fuel drying and passivation facility.

The results of the accident scenario under conditions of the No Action Alternative and the fuel drying and passivation facility are presented in Table 5.15-8.

Table 5.15-7. Assessment of secondary impacts of accidents for the Decentralization, 1992/1993 Planning Basis, Regionalization, and Centralization Alternatives.

Accident Description	Environmental or Social Factor							
	Biotic Resources	Water Resources	Economic Impacts	National Defense	Environmental Contamination	Endangered Species	Land Use	Treaty Rights/ Cultural Resources/ Native Cultures
New dry storage (cask impact with fire)	Minimal local effects	Possible temporary restriction of use of Columbia River for recreation	Clean-up costs locally, potential loss of crops	None anticipated	Moderate in immediate environs & offsite	None anticipated	Temporary restriction on agriculture pending radiological survey	Possible temporary restriction on access to traditional fishing sites
New process	a	a	a	a	a			

a a a
facility (U
metal fire)
New wet b b b b b
b b b
storage
(cask drop)

a. Consequences of this accident would be limited to very local onsite impact only, if any.
b. Consequences of this accident would be similar in nature to those of the 324 building or new dry storage facility (worst case) accidents; however they would be less severe because offsite concentrations would be lower by at least two orders of magnitude.

5.15.8 Construction and Occupational Accidents

Table 5.15-9 shows the predicted number of injuries, illnesses, and fatalities among workers from construction activities and operations activities for each alternative. Injury, illness, and fatality counts for construction workers are presented separately because of the relatively more hazardous nature of construction work.

Decentralization suboptions P and Q represent the highest predicted construction and occupational accident count of any of the alternatives. The higher number of accidents is attributable to increased construction and fuel processing required by these alternatives. The Centralization Onsite Alternative has accident counts similar to those for suboptions P and Q. The lowest accident counts are for the No Action Alternative and the Centralization Offsite Alternative. All other alternative are similar in their predicted accident counts.

5.16 Cumulative Impacts Including Past and Reasonably Foreseeable Actions

Cumulative impacts associated with implementing the alternatives for interim storage of SNF at the Hanford Site together with impacts from past and reasonably foreseeable future actions are described in the following subsections.

5.16.1 No Action Alternative

Cumulative impacts associated with implementation of the No Action Alternative are described in the following subsections.

5.16.1.1 Land Use. The Hanford Site consists of about 1450 square

kilometers (360,000 acres), of which about 87 square kilometers (22,000 acres) have been disturbed. Implementation of the No Action Alternative would not change that land use. Construction of the Environmental Restoration Disposal Facility will require disturbance of approximately 4.1 square kilometers (1.020 acres) of land. However, restoration of existing disturbed sites will compensate for this loss.

Table 5.15-8. Nonradiological exposure to public and workers to chemicals in spent nuclear fuel storage locations released during an accident.

Alternative/ Facility/ Chemical	Worker Exposure mg/m3	Exposure at Nearest Public Access mg/m3	Exposure at Nearest Public Residence mg/m3	ERPG 1a or TLV/TWA mg/m3	ERPG 2b or 0.1 IDLH mg/m3	ERPG 3c or IDLH mg/m3
No Action						
105-KE						

chlorine	4.30	4.30	0.13	2.9d	8.7	58
PCB	23.00	23.00	0.66	0.5	0.5	5
sodium hydroxide	140.00	140.00	0.40	2	20	200
sulfuric acid	220.00	220.00	6.40	2	10	30
105-KW						
chlorine	4.30	4.30	0.13	2.9	8.7	58
ethylene glycol	2.40	2.40	0.07	127	300	3000
kerosene	15.00	0.86	0.43	100	500	5000
polyacrylamide	4.20	0.24	0.12	0.03	400	4000
sodium hydroxide	140.00	140.00	0.40	2	20	200
sulfuric acid	220.00	220.00	6.40	2	10	30
PUREX (202A)						
cadmium nitrate tetrahydrate	0.03	0.03	0.02	0.05	10.5	105
diesel fuel	1.80	1.70	1.10	7	170	1700
mercury	7.20E-04	6.90E-04	4.30E-04	0.01	1	10
methanol	2.10E-04	2.00E-04	1.30E-04	262	3276	32760
PCB	0.00	0.00	0.00	0.5	0.5	5
sodium hydroxide	0.03	0.03	0.01	2	20	200
sodium nitrite	0.04	0.04	0.03	96	960	9600
T-Plant (221T)						
potassium permanganate	0.01	0.00	0.00	2	10	30
sodium	0.10	0.01	0.00	2	20	200
sodium hydroxide	0.02	0.01	0.00	2	20	200
sodium nitrite	0.05	0.00	0.00	96	960	9600
FFTF (403 Building)						
sodium	67.00	24.00	0.83	2	20	200
sodium potassium alloy	5.40	2.70	0.39	2	20	200
308 Building						
acetone	0.03	0.02	0.01	1780	2000	20000
ethylene glycol	70.00	57.00	37.00	127	300	3000
x-ray film (Ag)	88.00	0.77	0.36	0.01	62	620

Table 5.15-8 (contd)

Alternative/ Facility/ Chemical	Worker Exposure mg/m3	Exposure at Nearest Public Access mg/m3	Exposure at Nearest Public Residence mg/m3	ERPG 1a or TLV/TWA mg/m3	ERPG 2b or 0.1 IDLH mg/m3	ERPG 3c or IDLH mg/m3
324 Bldg						
alkyl dimethyl benzyl ammonium	29.00	1.90	0.24	10	13	130
bis-tri-n-butyltin oxide	38.00	2.40	0.31	0.1	20	200
poly oedmi ethylene dichloride	82.00	5.20	0.68	40	400	4000
325 Building						
mercury	3.20	0.20	0.03	0.01	1	10
poly oedmi ethylene	21.00	1.30	0.17			

```
40               400                 4000
dichloride
zinc                   0.04                                  0.00                 0.00
5                12.4                124
327 Building
poly oedmi ethylene    0.05                                  0.01                 0.04
40               400                 4000
dichloride
Decentralization
Suboption W
Wet Storage Facility
chlorine               0.75                                  0.10                 0.04
2.9              8.7                 58
PCB                    3.90                                  0.54                 0.20
0.5              0.5                 5
sodium hydroxide       36.00                                 1.10                 0.06
2                20                  200
sulfuric acid          39.00                                 5.30                 2.00
2                10                  30
Vault Dry Storage
Facility
no chemicals of
concern
Decentralization
Suboption X
Wet Storage Facility
chlorine               0.75                                  0.10                 0.04
2.9              8.7                 58
PCB                    3.90                                  0.54                 0.20
0.5              0.5                 5
sodium hydroxide       36.00                                 1.10                 0.06
2                20                  200
sulfuric acid          39.00                                 5.30                 2.00
2                10                  30
Casks Dry Storage
Facility
no chemicals of
concern
Decentralization
Suboption Y
Vault Dry Storage
Facility
no chemicals of
concern
Shear\Leach\Calcine
Stabilization Facility
diesel fuel            0.42                                  0.40                 0.26
7                170                 1700
nitric acid            21.00                                 20.00                13.00
2                25.8                258
sodium hydroxide       0.86                                  0.73                 0.20
2                20                  200
sodium nitrite         0.11                                  0.10                 0.06
96               960                 9600
sulfuric acid          0.53                                  0.51                 0.32
2                10                  30
Table 5.15-8  (contd)
Alternative/           Worker                                Exposure at          Exposure at
ERPG 1a or       ERPG 2b or          ERPG 3c or
Facility/              Exposure                              Nearest Public       Nearest Public
TLV/TWA          0.1 IDLH            IDLH
Chemical               mg/m3                                 Access mg/m3         Residence mg/m3
mg/m3            mg/m3               mg/m3

Decentralization
Suboption Z
Casks Dry Storage
Facility
no chemicals of
concern
Shear\Leach\Calcine
Stabilization Facility
diesel fuel            0.42                                  0.40                 0.26
7                170                 1700
nitric acid            21.00                                 20.00                13.00
2                25.8                258
sodium hydroxide       0.86                                  0.73                 0.20
2                20                  200
sodium nitrite         0.11                                  0.10                 0.06
96               960                 9600
sulfuric acid          0.53                                  0.51                 0.32
```

				2	10	30
Decentralization Suboption P						
105-KE						
chlorine	4.30	4.30	0.13	2.9	8.7	58
PCB	23.00	23.00	0.66	0.5	0.5	5
sodium hydroxide	140.00	140.00	0.40	2	20	200
sulfuric acid	220.00	220.00	6.40	2	10	30
105-KW						
chlorine	4.30	4.30	0.13	2.9	8.7	58
ethylene glycol	2.40	2.40	0.07	127	300	3000
kerosene	15.00	0.86	0.43	100	500	5000
polyacrylamide	4.20	0.24	0.12	0.03	400	4000
sodium hydroxide	140.00	140.00	0.40	2	20	200
sulfuric acid	220.00	220.00	6.40	2	10	30
Shear\Leach\Calcine Stabilization Facility						
diesel fuel	0.42	0.40	0.26	7	170	1700
nitric acid	21.00	20.00	13.00	2	25.8	258
sodium hydroxide	0.86	0.73	0.20	2	20	200
sodium nitrite	0.11	0.10	0.06	96	960	9600
sulfuric acid	0.53	0.51	0.32	2	10	30
Decentralization Suboption Q						
105-KE						
chlorine	4.30	4.30	0.13	2.9	8.7	58
PCB	23.00	23.00	0.66	0.5	0.5	5
sodium hydroxide	140.00	140.00	0.40	2	20	200
sulfuric acid	220.00	220.00	6.40	2	10	30

Table 5.15-8 (contd)

Alternative/ Facility/ Chemical	Worker Exposure mg/m3	Exposure at Nearest Public Access mg/m3	Exposure at Nearest Public Residence mg/m3	ERPG 1a or TLV/TWA mg/m3	ERPG 2b or 0.1 IDLH mg/m3	ERPG 3c or IDLH mg/m3
105-KW						
chlorine	4.30	4.30	0.13	2.9	8.7	58
ethylene glycol	2.40	2.40	0.07	127	300	3000
kerosene	15.00	0.86	0.43	100	500	5000
polyacrylamide	4.20	0.24	0.12	0.03	400	4000
sodium hydroxide	140.00	140.00	0.40	2	20	200
sulfuric acid	220.00	220.00	6.40	2	10	30
Solvent Extraction Fuel Stabilization Facility						
cadmium nitrate tetrahydrate	0.03	0.03	0.02	0.05	10.5	105
diesel fuel	0.42	0.40	0.26	7	170	1700
hydrazine	0.02	0.02	0.01	0.13	10.5	104.8
kerosene	0.84	0.81	0.51	100	500	5000

nitric acid	21.00	20.00	13.00	5.2	25.8	258
potassium permanganate	0.00	0.00	0.00	2	10	30
sodium hydroxide	0.86	0.73	0.20	2	20	200
sodium nitrite	0.11	0.10	0.06	96	960	9600
sulfuric acid	0.53	0.51	0.32	2	10	30
1992/1993 Planning Basis same as Decentralization						
Regionalization same as Decentralization						
Centralization Onsite same as No Action for first 5 years, then same as Decentralization						
Centralization Offsite same as No Action for first 5 years, then same as fuel drying and passivation facility						
Fuel Drying and Passivation Facility						
diesel fuel	0.42	0.40	0.26	7	170	1700

Table 5.15-8 (contd)

Alternative/ Facility/ Chemical	Worker Exposure mg/m3	Exposure at Nearest Public Access mg/m3	Exposure at Nearest Public Residence mg/m3	ERPG 1a or TLV/TWA mg/m3	ERPG 2b or 0.1 IDLH mg/m3	ERPG 3c or IDLH mg/m3
sodium hydroxide	0.09	0.07	0.02	2	20	200
sodium nitrite	0.11	0.10	0.06	96	960	9600
sulfuric acid	0.53	0.51	0.32	2	10	30

a. Emergency Response Planning Guideline (ERPG) value 1 (irritation or odor), or Threshold Limit Values/Time Weighted Averages (TLV/TWA), or value for a similar toxicological end point from toxicological data in the Registry of Toxic Effects for Chemical Substances (RTEC).
b. ERPG 2 (irreversible health effects), or 0.1 of Immediately Dangerous to Life and Health (IDLH), or value for a similar toxicological end point from toxicological data in RTEC.
c. ERPG 3 (death), IDLH, or value for a similar toxicological end point from toxicological data in RTEC.
d. Bold italic type indicates that the toxicological limit was exceeded at one or more exposure points.

Table 5.15-9. Estimated injuries, illnesses, and fatalities of workers expected during construction and operation of facilities in each alternative (cumulative totals through 2035).

Alternative	Construction Workersa		Operations Workersa		Total Workers	
	Injury & illness (persons)	Fatalities (persons)	Injury & illness (persons)	Fatalities (persons)	Injury & illness (persons)	Fatalities (persons)
No Actionb	0	0	231	0	231	0
Decentralization						
Suboption W	54	0	83	0	137	0
Suboption X	49	0	84	0	133	0
Suboption Yc	79	0	69	0	148	0
Suboption Zc	48	0	69	0	117	0

Suboption Pc	183	0	84	0	267	0
Suboption Qc	223	0	139	0	362	1
1992/3 Planning Basis	same as Decentralization					
Regionalization						
Suboption AX	38	0	82	0	120	0
Suboption AYc	74	0	69	0	143	0
Suboption AZc	37	0	69	0	106	0
Suboption B1d	99	0	109	0	208	0
Suboption B2d	211	0	136	0	347	1
Suboptions C	same as Centralization offsite					
Centralization Onsited	285	0	205	0	490	1
Centralization Offsite	154	0	84	0	238	0

a. Facility construction and operation estimates are based on DOE and DOE contractor accident rates (See Volume 2, Part B, Table F-4-7 of this EIS).
b. Worker year estimates from Bergsman (1995).
c. Dry storage suboptions (Y or Z) would be paired with either of two processing options (P or Q).
d. These estimates represent incremental increases for fuel imported from offsite locations only; estimates for storage (and stabilization where required) of onsite fuel woule be the same as in the Decentralization Alternative.

5.16.1.2 Air Quality. Air quality limits (WAC 173-470-030,-100) at the

Hanford Site boundary are not expected to be approached as a result of implementing the No Action Alternative or from reasonably foreseeable additions to the Hanford Site, e.g., construction and operation of a Laser Interferometer Gravitational-Wave Observatory or from decommissioning of unused facilities or site restoration activities.

5.16.1.3 Waste Management. Under the No Action Alternative, there

would be a continuing generation of about 100 cubic meters of low-level wastes per year from incidental activities and about 530 cubic meters during containerization of SNF and sludge in the 100-K Area basins. All presently anticipated activities on the Hanford Site would result in approximately 20,000 cubic meters of low-level waste per year. Thus, at a maximum, the total quantity of low-level waste from SNF activities would account for about 5 percent of the annual quantity of low-level waste generated at the Hanford Site.

5.16.1.4 Socioeconomics. Under the No Action Alternative, the SNF

workforce would remain the same, about 60 workers. The Hanford Site workforce is expected to drop from about 18,700 in 1995 to 14,700 in 1997 and to remain approximately at 14,700 through 2004. The regional workforce is expected to range from 81,000, to 86,000 in that same period.

5.16.1.5 Occupational and Public Health. The cumulative population

dose since plant startup was estimated to be about 100,000 person-rem (estimated to one significant figure; Section 4.12.2.4.2). The number of inferred fatal cancers since plant startup would amount to about 50 (essentially all of which would be attributed to dose received in the 1945-52 time frame). In the 50 years since plant startup, the population of interest (assuming a constant population of 380,000 and an individual dose of about 0.3 rem/year) would have received about 5,000,000 person-rem from naturally occurring radiation sources (natural background) which would relate to about 2,500 latent cancer fatalities. In the same 50 years about 27,000 cancer fatalities from all causes would have been expected in that population.

If the Hanford sitewide contribution to public dose from all exposure pathways is considered (0.8 person-rem per year from DOE facilities and 0.7 person-rem per year from Washington Public Power Supply System reactor operation for 40 years), it is estimated that the cumulative collective dose would be approximately 60 person-rem. No latent fatal cancers would be expected from such a dose. Over 40 years of interim storage of SNF, the population of interest would have received 4,000,000 person-rem from natural background radiation. That dose would relate to 2,000 latent cancer fatalities. In the same 40 years, about 21,000 cancer fatalities from all causes would be expected among the population in the region of interest (380,000 population).

Air quality limits [(40 CFR 61 Subpart H), 10 millirem per year at the Hanford Site boundary] are not expected to be approached as a result of implementing the No Action Alternative or from reasonably foreseeable additions to the Hanford Site, e.g., construction and operation of a Laser Interferometer Gravitational-Wave Observatory or from decommissioning of unused facilities or site restoration activities.

Cumulative spent fuel worker dose from plant startup to date was estimated at about 2,000 person-rem (Section 4.12.1.2), from which one fatal cancer might be inferred. In the near term the annual increments to cumulative worker dose would be expected to be about 24 person-rem. No latent fatal cancers would be expected from 40 years of the No Action Alternative (960 person-rem).

The cumulative worker dose since start up of activities at the Hanford Site is about 90,000 person-rem, to which would be added about 210 person-rem/yr for a total cumulative worker dose of about 100,000 person-rem through the next 40 years. Thus for 90 years of Hanford operations, about 50 latent cancer fatalities (LCFs) might be inferred (4 LCFs inferred from 1995 onward). In those 90 years about 4,500 LCFs would be inferred from natural background radiation and 48,000 LCFs from all causes would be expected.

Although the worker dose assocated with all future site restoration activities is expected to be small in comparison with cumulative worker dose to date, it is too speculative to quantify at this time.

5.16.2 Decentralization Alternative

Cumulative impacts associated with implementation of the Decentralization Alternative are described in the following subsections.

5.16.2.1 Land Use. The Hanford Site consists of about 1450 square

kilometers (360,000 acres), of which about 87 square kilometers (22,000 acres) have been disturbed. Implementation of the Decentralization Alternative would disturb an additional area of up to 0.6 square kilometers (160 acres) for a total of about 88 square kilometers (22,000 acres). The amount of land actually occupied by new facilities would range from about 4 ha (11 acres) to about 7 hectares (18 acres). Construction of the Environmental Restoration Disposal Facility will require disturbance of approximately 4.1 square kilometers (1.020 acres) of land. However, restoration of existing disturbed sites will compensate for this loss.

5.16.2.2 Air Quality. Air quality limits (WAC 173-470-030,-100) at the

Hanford Site boundary are not expected to be approached as a result of implementing any of the options in the Decentralization Alternative or from reasonably foreseeable additions to the Hanford Site, e.g., construction and operation of a Laser Interferometer Gravitational-Wave Observatory or from decommissioning of unused facilities or restoration activities.

5.16.2.3 Waste Management. In the near term under the Decentralization

Alternative, there would be about 530 cubic meters of low-level waste generated during 2 years of repackaging and containerization of SNF and sludge in the 100-K Basins. Thereafter low-level waste generation would range from 41 to 420 cubic meters per year for about 4 years depending on suboption selected. All presently anticipated activities on the Hanford Site would result in approximately 20,000 cubic meters of low-level waste per year. Thus, at a maximum, the total low-level waste from SNF activities would account for about 8 percent of the annual quantity of low-level waste generated at the Hanford Site.

High-level waste that might be generated in the Decentralization Alternative would not add significantly to the more than 250,000 cubic meters of waste at Hanford currently handled as high-level waste.

5.16.2.4 Socioeconomics. Under the Decentralization Alternative, the

SNF workforce would increase from 80 to about 740. The Hanford Site workforce is expected to drop from 18,700 in 1995 to 14,700 in 1997 and remain at approximately 14,700 through 2004. The regional workforce is expected to range from 81,000, to 86,000 in that same period. The maximum change with respect to the regional workforce would be an increase of about 0.9 percent.

5.16.2.5 Occupational and Public Health. The cumulative population

dose since plant startup was estimated to be about 100,000 person-rem (estimated to one significant figure; Section 4.12.2.4.2). The number of inferred fatal cancers since plant startup would amount to about 50 (essentially all of which would be attributed to dose received in the 1945-52 time frame). In the 50 years since plant startup, the population of interest (assuming a constant population of 380,000 and an individual dose of about 0.3 rem/year) would have received about 5,000,000 person-rem from naturally occurring radiation sources (natural background), which would relate to 2,500 latent cancer fatalities. In the same 50 years about 27,000 cancer fatalities from all causes would have been expected in the region of interest.

If the Hanford sitewide contribution to public dose from all exposure pathways is considered (0.8 person-rem per year from DOE facilities and 0.7 person-rem per year from Washington Public Power Supply System reactor operation for 40 years), it is estimated that the cumulative collective dose would be approximately 60 person-rem. Additional collective population dose from implementation of the Decentralization Alternative would range from 1 to 4 person-rem over 40 years (dose from 4 years of processing would dominate). Thus, in total, the collective population dose from man-made sources would remain approximately 60 person-rem. No latent fatal cancers would be expected from such a dose. Over 40 years of interim storage of SNF, the population of interest would have received 4,000,000 person-rem from naturally occurring radiation sources (natural background). That dose would relate to 2,000 latent cancer fatalities. In the same 40 years, about 21,000 cancer fatalities from all causes would be expected among the population in the region of interest (380,000 population).

Air quality limits [(40 CFR 61 Subpart H), 10 millirem per year at the Hanford Site boundary] are not expected to be approached as a result of implementing the Decentralization Alternative or from reasonably foreseeable additions to the Hanford Site, e.g., construction and operation of a Laser Interferometer Gravitational-Wave Observatory or decommissioning of unused facilities, or site restoration activities.

Cumulative spent fuel worker dose from plant startup to date was estimated at about 2,000 person-rem (Section 4.12.1.2), from which one latent fatal cancer might be inferred. Collective worker dose from SNF activities would amount to about 80 person-rem for maintenance and operations, 18 person-rem for loading storage facilities, and 180 to 320 person-rem depending on processing option selected. Thus, the total collective 40-year worker dose from SNF activities would be from about 300 to 420 person-rem. Within the accuracy of the estimates, cumulative worker dose in the Decentralization Alternative would not add significantly to the cumulative Hanford Site worker dose over 90 years as described for the No Action Alternative.

5.16.3 1992/1993 Planning Basis Alternative

Because of the similarity of activities, cumulative impacts of the 1992/1993 Planning Basis Alternative would be essentially the same as those described for the Decentralization Alternative.

5.16.4 Regionalization Alternative (Options A, B1, B2, and C)

Cumulative impacts for implementation of the four Regionalization Subalternatives are described in the following subsections.

5.16.4.1 Regionalization Option A . Cumulative impacts associated with

implementation of the Regionalization Option A where Hanford's defense SNF is stored at the Hanford Site and other SNF is shipped offsite for storage are described in the following subsections.

5.16.4.1.1 Land Use.

The Hanford Site consists of about 1450 square kilometers (360,000 acres) of which about 87 square kilometers (22,000 acres) have been disturbed. Implementation of Regionalization Option A would disturb an additional area of up to 0.6 square kilometers (160 acres), for a total of about 88 square kilometers (22,000 acres). The amount of land actually occupied by new facilities would range from about 2 hectares (6 acres) to about 7 hectares (18 acres). Construction of the Environmental Restoration Disposal Facility will require disturbance of approximately 4.1 square kilometers (1.020 acres) of land. However, restoration of existing disturbed sites will compensate for this loss.

5.16.4.1.2 Air Quality.

Air quality limits (WAC 173-470-030,-100) at the Hanford Site boundary are not expected to be approached as a result of implementing any of the options in the Regionalization A Alternative or from reasonably foreseeable additions to the Hanford Site, e.g., construction and operation of a Laser Interferometer Gravitational-Wave Observatory or from decommissioning of unused facilities or restoration activities.

5.16.4.1.3 Waste Management.

In the near term under Regionalization Option A, there would be about 530 cubic meters of low-level waste generated during containerization of SNF and sludge in the 100-K basins. Thereafter, low-level waste generation would range from 61 to 420 cubic meters per year for about 4 years depending on option selected.. All presently anticipated activities on the Hanford Site would result in approximately 20,000 cubic meters of low-level waste per year. Thus, at a maximum, the total low-level waste from SNF activities would account for about 8 percent of the annual Hanford generation of low-level waste.

High-level waste that might be generated in Regionalization A would not add significantly to the more than 250,000 cubic meters of waste at Hanford currently handled as high-level waste.

5.16.4.1.4 Socioeconomics.

Under Regionalization Option A, the SNF workforce would increase by 60 to about 470. The Hanford Site workforce is expected to drop from about 18,700 in 1995 to about 14,700 in 1997 and to remain at approximately 14,700 through 2004. The regional workforce is expected to range from 81,000, to 86,000 in that same period. The maximum change with respect to the regional workforce would be an increase of about 0.6 percent.

5.16.4.1.5 Occupational and Public Health.

The cumulative population dose since plant startup was estimated to be about 100,000 person-rem (estimated to one significant figure; Section 4.12.2.4.2). The number of inferred fatal cancers since plant startup would amount to about 50 (essentially all of which would be attributed to exposures in the 1945-52 time frame). In the 50 years since plant startup the population of interest (assuming a constant population of 380,000 and an individual dose of about 0.3 rem/year) would have received about 5,000,000 person-rem from naturally occurring radiation sources (natural background), which would relate to 2,500 latent cancer fatalities. In the same 50 years about 27,000 cancer fatalities from all causes would have been expected in the region of interest.

If the Hanford sitewide contribution to public dose from all exposure pathways is considered (0.8 person-rem per year from DOE facilities and 0.7 person-rem per year from Washington Public Power Supply System reactor operation for 40 years), it is estimated that the cumulative collective dose would be approximately 60 person-rem. Additional collective population dose from implementation of Regionalization Option A would range from 1 to 4 person-rem over 40 years (dose from 4 years of processing would dominate). Thus, in total, the collective population dose from man-made sources would be about 60 person-rem. No latent fatal cancers would be expected from such a dose. Over 40 years of interim storage of SNF, the population of interest would have received 4,000,000 person-rem from naturally occurring radiation sources (natural background). That dose would relate to 2,000 latent cancer fatalities. In the same 40 years, about 21,000 cancer fatalities from all causes would be expected among the population in the region of interest (380,000 population).

Air quality limits ([40 CFR 61 Subpart H], 10 millirem per year at the Site boundary) are not expected to be approached as a result of implementing the Regionalization Alternative or from reasonably foreseeable additions to the Hanford Site, e.g., construction and operation of a Laser Interferometer Gravitational-Wave Observatory, or decommissioning of unused facilities, or site restoration activities.

Cumulative spent fuel worker dose from plant startup to date was estimated at about 2,000 person-rem (Section 4.12.1.2), from which one latent fatal cancer might be inferred. Collective worker dose from SNF activities would amount to about 80 person-rem for maintenance and operations, 18 person-rem for loading storage facilities, and 180 to 320 person-rem depending on processing option selected. Thus the total collective 40-year worker dose would be from about 300 to 420 person-rem. Within the accuracy of the estimates, cumulative worker dose in Regionalization A would not add significantly to the cumulative Hanford Site work dose over 90 years as described for the No Action Alternative.

5.16.4.2 Regionalization Option B1. Cumulative impacts associated with

the implementation of Regionalization Option B1, where all SNF west of the Mississippi River, except for Naval SNF, is transported to Hanford are described in the following subsections.

5.16.4.2.1 Land Use.

The Hanford Site consists of about 1450 square kilometers (360,000 acres), of which about 87 square kilometers (22,000 acres) have been disturbed. Implementation of Regionalization Option B1 would disturb an additional area of upto 0.6 square kilometers (160 acres), for a total of about 88 square kilometers (22,000 acres). The amount of land actually occupied by new facilities would range from about 15 hectares (36 acres) to about 28 hectares (68 acres). Construction of the Environmental Restoration Disposal Facility will require disturbance of approximately 4.1

square kilometers (1.020 acres) of land. However, restoration of existing disturbed sites will compensate for this loss.

5.16.4.2.2 Air Quality.

Air quality limits (WAC 173-470-030,-100) at the Hanford Site boundary are not expected to be approached as a result of implementing any of the options in Regionalization Option B1 or from reasonably foreseeable additions to the Hanford Site, e.g., construction and operation of a Laser Interferometer Gravitational-Wave Observatory or from decommissioning of unused facilities or restoration activities.

5.16.4.2.3 Waste Management.

In the near term under Regionalization Option B1, there would be about 530 cubic meters of low-level waste generated during repackaging and containerization of SNF and sludge in 100-K Basins. Thereafter low-level waste generation would range from 61 to 420 cubic meters per year for about 4 years depending on the suboption selected. All presently anticipated processing activities on the Hanford Site would result in approximately 20,000 cubic meters of low-level waste per year. Thus, the total quantity of low-level waste from SNF activities would account for about 8 percent of the annual quantity of low-level waste generated at the Hanford Site.

High-level waste that might be generated in Regionalization B1 would not add significantly to the more than 250,000 cubic meters of waste at Hanford currently handled as high-level waste.

5.16.4.2.4 Socioeconomics.

Under Regionalization Option B1, the SNF workforce would increase by about 170 to about 800. The Hanford Site workforce is expected to drop from 18,700 in 1995 to 14,700 in 1997 and remain around 14,700 through 2004. The regional workforce is expected to range from 81,000, to 86,000 in that same period. The maximum change with respect to the regional workforce would be an increase of about 1 percent.

5.16.4.2.5 Occupational and Public Health.

The cumulative population dose since plant startup was estimated to be about 100,000 person-rem (estimated to one significant figure; Section 4.12.2.4.2). The number of inferred fatal cancers since plant startup would amount to about 50 (essentially all of which would be attributed to exposures in the 1945-52 time frame). In the 50 years since plant startup, the population of interest (assuming a constant population of 380,000) would have received about 5,000,000 person-rem from naturally occurring radiation sources (natural background), which would relate to 2,500 latent cancer fatalities. In the same time, about 27,000 cancer fatalities from all causes would have been expected in the region of interest.

If the Hanford sitewide contribution to public dose from all exposure pathways is considered (0.8 person-rem per year from DOE facilities and 0.7 person-rem per year from Washington Public Power Supply System reactor operation for 40 years), it is estimated that the cumulative collective dose would be approximately 60 person-rem. Additional collective population dose from implementation of Regionalization Option B1 would range from 1 to 4 person-rem over 40 years (dose from 4 years of processing would dominate). Thus, in total, the collective population dose from man-made sources would remain approximately 60 person-rem. No latent fatal cancers would be expected from such a dose. Over 40 years of interim storage of SNF, the population of interest would have received 4,000,000 person-rem from naturally occurring radiation sources (natural background). That dose would relate to 2,000 latent cancer fatalities. In the same 40 years, about 21,000 cancer fatalities from all causes would be expected among the population in the region of interest (380,000 population).

Air quality limits [(40 CFR 61 Subpart H), 10 millirem per year at the Hanford Site boundary] are not expected to be approached as a result of implementing Regionalization Option B1 or from reasonably foreseeable additions to the Hanford Site, e.g., construction and operation of a Laser Interferometer Gravitational-Wave Observatory or from decommissioning of unused facilities or site restoration activities.

Cumulative spent fuel worker dose from plant startup to date was estimated at about 2,000 person-rem (Section 4.12.1.2), from which one latent fatal cancer might be inferred. Collective worker dose from SNF activities would amount to about 80 person-rem for maintenance and operations, 18 person-rem for loading storage facilities, and 180 to 320 person-rem depending on processing option selected. Thus the total collective 40-year worker dose would be from about 300 to 420 person-rem. Within the accuracy of the estimates, cumulative worker dose in Regionalization B1 would not add significantly to the cumulative Hanford Site worker dose over 90 years as described for the No Action Alternative.

5.16.4.3 Regionalization Option B2. Cumulative impacts associated

with the implementation of Regionalization Option B2, where all SNF west of the Mississippi River and Naval SNF, are transported to Hanford are described in the following subsections.

5.16.4.3.1 Land Use.

The Hanford Site consists of about 1450 square kilometers (360,000 acres) of which about 87 square kilometers (22,000 acres) have been disturbed. Implementation of Regionalization Option B2 would disturb an additional area of up to 0.6 square kilometers (160 acres), for a total of about 88 square kilometers (22,000 acres). The amount of land actually occupied by new facilities would range from about 21 hectares (52 acres) to about 30 hectares (74 acres). Construction of the Environmental Restoration Disposal Facility will require disturbance of approximately 4.1 square kilometers (1.020 acres) of land. However, restoration of existing disturbed sites will compensate for this loss.

5.16.4.3.2 Air Quality.

Air quality limits (WAC 173-470-030,-100) at the Hanford Site boundary are not expected to be approached as a result of implementing any of the suboptions in Regionalization Option B1 or from reasonably foreseeable additions to the Hanford Site, e.g., construction and operation of a Laser Interferometer Gravitational-Wave Observatory, or from decommissioning of unused facilities or restoration activities.

5.16.4.3.3 Waste Management.

In the near term under Regionalization Option B2, there would be about 530 cubic meters of low-level waste generated during repackaging and containerization of SNF and sludge in the 100-K Basins. Thereafter, low-level waste generation would range from 61 to 420 cubic meters per year. All presently anticipated activities on the Hanford Site would result in approximately 20,000 cubic meters of low-level waste per year. Thus, at a maximum, the total quantity of low-level waste from SNF activities would account for about 4 percent of the annual quantity of low-level waste generated at the Hanford Site.

High-level waste that might be generated in Regionalization B2 would not add significantly to the more than 250,000 cubic meters of waste at Hanford currently handled as high-level waste.

5.16.4.3.4 Socioeconomics.

Under Regionalization Option B2, the SNF workforce would increase by about 170 to about 800. The Hanford Site workforce is expected to drop from 18,700 in 1995 to 14,700 in 1997 and remain around 14,700 through 2004. The regional workforce is expected to range from 81,000, to 86,000 in that same period. The maximum change with respect to the regional workforce would be an increase of about 1 percent.

5.16.4.3.5 Occupational and Public Health.

The cumulative population dose since plant startup was estimated to be about 100,000 person-rem (estimated to one significant figure; Section 4.12.2.4.2). The number of inferred fatal cancers since plant startup would amount to about 100 (essentially all of which would be attributed to exposures in the 1945-52 time frame). In the 50 years since plant startup, the population of interest (assuming a constant population of 380,000) would have received about 5,000,000 person-rem from naturally occurring radiation sources (natural background) which would relate to 2,500 latent cancer fatalities. In the same time about 27,000 cancer fatalities from all causes would have been expected in the region of interest.

If the Hanford Site contribution from all exposure pathways to public dose is added (0.8 person-rem per year from DOE facilities and 0.7 person-rem per year from Washington Public Power Supply System reactor operation for 40 years), it is estimated that the cumulative collective dose would be approximately 60 person-rem. Additional collective population dose from implementation of Regionalization Option B2 would range from 1 to 4 person-rem over 40 years (dose from 4 years of processing would dominate). Thus, in total, the collective population dose from man-made sources would remain approximately 60 person-rem. No latent fatal cancers would be expected from such a dose. Over 40 years of interim storage of SNF, the population of interest would have received 4,000,000 person-rem from naturally occurring radiation sources (natural background). That dose would relate to 2,000 latent cancer fatalities. In the same 40 years, about 21,000 cancer fatalities from all causes would be expected among the population in the region of interest (380,000 population).

Air quality limits [(40 CFR 61 Subpart H), 10 millirem per year at the Site boundary] are not expected to be approached as a result of implementing Regionalization Option B2 or from reasonably foreseeable additions to the Hanford Site, e.g., construction and operation of a Laser Interferometer Gravitational-Wave Observatory, or decommissioning of unused facilities or site restoration activities.

Cumulative spent fuel worker dose from plant startup to date was estimated at about 2,000 person-rem (Section 4.12.1.2), from which one latent fatal cancer might be inferred. Collective worker dose from SNF activities would amount to about 80 person-rem for maintenance and operations, 18 person-rem for loading storage facilities, and 180 to 320 person-rem depending on the processing suboption selected. Thus the total collective 40-year worker dose would be from about 300 to 420 person-rem. Within the accuracy of the estimates, cumulative worker dose in Regionalization B2 would not add significantly to the cumulative Hanford Site worker dose over 90 years as described for the No Action Alternative.

5.16.4.4 Regionalization C Option. Cumulative impacts in this option,

where all Hanford SNF is sent to INEL or NTS, would be essentially the same as those described for the Centralization Alternative, minimum option.

5.16.5 Centralization Alternative

Cumulative impacts associated with implementation of one or the other of two options under the Centralization Alternative are described in the following subsections.

5.16.5.1 Centralization Alternative Maximum Option. Cumulative impacts

associated with implementation of the Centralization Alternative maximum option, where all SNF is sent to the Hanford Site, are described in the following subsections.

5.16.5.1.1 Land Use.

The Hanford Site consists of about 1450 square kilometers (360,000 acres), of which about 87 square kilometers (22,000 acres) have been disturbed. Implementation of the Centralization Alternative maximum option would disturb up to an additional area of about 0.6 square kilometers (160 acres) for a total of about 88 square kilometers (22,000 acres). The amount of land actually occupied by new facilities would range from about 35 hectares (86 acres) to about 38 hectares (93 acres). Construction of the Environmental Restoration Disposal Facility will require disturbance of approximately 4.1 square kilometers (1.020 acres) of land. However, restoration of existing disturbed sites will compensate for this loss.

5.16.5.1.2 Air Quality.

Air quality limits (WAC 173-470-030,-100) at the Hanford Site boundary are not expected to be approached as a result of implementing any of the suboptions in the Centralization Alternative maximum option or from reasonably foreseeable additions to the Hanford Site, e.g., construction and operation of a Laser Interferometer Gravitational-Wave Observatory, or from decommissioning unused facilities or restoration activities.

5.16.5.1.3 Waste Management.

In the near term under the Centralization Alternative maximum option, there would be about 532 cubic meters of low-level waste generated during repackaging and containerization of SNF and sludge in the 100-K Basins. Thereafter, low-level waste generation would amount to about 140 cubic meters per year. All presently anticipated activities on the Hanford Site would result in approximately 20,000 cubic meters of low-level waste per year. Thus, at a maximum, SNF activities would account for about 1 percent of the total.

High-level waste that might be generated in the Centralization maximum option would not add significantly to the more than 250,000 cubic meters of waste at Hanford currently handled as high-level waste.

5.16.5.1.4 Socioeconomics.

Under the Centralization Alternative maximum option, the SNF workforce would increase by about 290 to about 900. The Hanford Site workforce is expected to drop from 18,700 in 1995 to 14,700 in 1997 and remain around 14,700 through 2004. The regional workforce is expected to range from 81,000, to 86,000 in that same period. The maximum change with respect to the regional workforce would be an increase of about 1 percent.

5.16.5.1.5 Occupational and Public Health.

The cumulative population dose since plant startup was estimated to be about 100,000 person-rem (estimated to one significant figure; Section 4.12.2.4.2). The number of inferred fatal cancers since plant startup would amount to about 50 (essentially all of which would be attributed to exposures in the 1945-52 time frame). In the 50 years since plant startup, the population of interest (assuming a constant population of 380,000) would have received 5,000,000 person-rem from naturally occurring radiation sources (natural background), which would relate to 2,500 latent cancer fatalities. In the same time about 27,000 cancer fatalities from all causes would have been expected in the region of interest .

If the Hanford sitewide contribution to public dose from all exposure pathways is considered (0.8 person-rem per year from DOE facilities and 0.7 person-rem per year from Washington Public Power Supply System reactor operation for 40 years), it is estimated that the cumulative collective dose would be approximately 60 person-rem. Additional collective population dose from implementation of the Centralization Alternative maximum option would range from 1 to 4 person-rem over 40 years (dose from 4 years of processing would dominate). Thus, in total, the collective population dose from man-made sources would remain approximately 60 person-rem. No latent fatal cancers would be expected from such a dose. Over 40 years of interim storage of SNF, the population of interest would have received 4,000,000 person-rem from naturally occurring radiation sources (natural background). That dose would relate to 2,000 latent cancer fatalities. In the same 40 years, about 21,000 cancer fatalities from all causes would be expected among the population in the region of interest (380,000 population).

Air quality limits [(40 CFR 61 Subpart H), 10 millirem per year at the Hanford Site boundary] are not expected to be approached as a result of implementing the Centralization Alternative maximum option or from reasonably foreseeable additions to the Hanford Site, e.g., construction and operation of a Laser Interferometer Gravitational-Wave Observatory, or decommissioning of unused facilities or site restoration activities.

Cumulative spent fuel worker dose from plant startup to date was estimated at about 2,000 person-rem (Section 4.12.1.2), from which one latent fatal cancer might be inferred. Collective worker dose from SNF activities in the Centralization Alternative maximum option would amount to about 80 person-rem for maintenance and operations, 18 person-rem for loading storage facilities, and 180 to 320 person-rem depending on processing suboption selected.

Within the accuracy of the estimates, cumulative worker dose in the Centralization maximum option would not add significantly to the cumulative Hanford Site worker dose over 90 years as described for the No Action Alternative.

5.16.5.2 Centralization Alternative Minimum Option. Cumulative impacts

associated with implementation of the Centralization Alternative minimum option, where all SNF on the Hanford Site is shipped offsite for storage, are described in the following subsections.

5.16.5.2.1 Land Use.

The Hanford Site consists of about 1450 square kilometers (360,000 acres) of which about 87 square kilometers (22,000 acres) have been disturbed. Implementation of the Centralization Alternative minimum option would disturb up to an additional area of about 0.6 square kilometers (160 acres) for a total of about 88 square kilometers (22,000 acres). The amount of land actually occupied by new facilities would range from about 2 hectares (6 acres) to about 15 hectares (12 acres). Construction of the Environmental Restoration Disposal Facility will require disturbance of approximately 4.1 square kilometers (1.020 acres) of land. However, restoration of existing disturbed sites will compensate for this loss.

5.16.5.2.2 Air Quality.

Air quality limits (WAC 173-470-030,-100) at the Hanford Site boundary are not expected to be approached as a result of implementing the any of the suboptions in the Centralization Alternative minimum option or from reasonably foreseeable additions to the Hanford Site, e.g., construction and operation of a Laser Interferometer Gravitational-Wave Observatory, or from decommissioning unused facilities or restoration activities.

5.16.5.2.3 Waste Management.

In the near term under the Centralization Alternative minimum option, there would be about 532 cubic meters of low-level waste generated during repackaging and containerization of SNF and sludge in the 100-K Basins. Thereafter, low-level waste generation would range from 110 to 490 cubic meters per year. All presently anticipated activities on the Hanford Site would result in approximately 21,000 cubic meters of solid waste per year. Thus, at a maximum, SNF activities would account for about 2 percent of the annual generation of low-level waste at the Hanford Site.

High-level waste that might be generated in the Centralization mininim option would not add significantly to the more than 250,000 cubic meters of waste at Hanford currently handled as high-level waste.

5.16.5.2.4 Socioeconomics.

Under the Centralization Alternative minimum option, the SNF workforce would increase by about 390 to about 590. The Hanford Site workforce is expected to remain at about 18,000 from 1995 through 2004. The regional workforce is expected to range from 81,000, to 86,000 in that same period. The maximum change with respect to the regional workforce would be an increase of about 0.7 percent.

5.16.5.2.5 Occupational and Public Health.

The cumulative population dose since plant startup was estimated to be about 200,000 person-rem (estimated to one significant figure; Section 4.12.2.4.2). The number of inferred fatal cancers since plant startup would amount to about 50 (essentially all of which would be attributed to exposures in the 1945-52 time frame). In the 50 years since plant startup, the population of interest (assuming a constant population of 380,000) would have received 5,000,000 person-rem from naturally occurring radiation sources (natural background), which would relate to 2,500 latent cancer fatalities. In the same time about 24,000 cancer fatalities from all causes would have been expected in the region of interest.

Cumulative spent fuel worker dose from plant startup to date was estimated at about 2,000 person-rem (Section 4.12.1.2), from which one latent fatal cancer might be inferred. Collective worker dose from SNF activities in the Centralization Alternative minimum option would amount to about 80 person-rem for maintenance and operations, 18 person-rem for loading storage facilities, and 180 to 320 person-rem depending on processing suboption selected. Thus the total collective 40-year worker dose would be from about 300 to 420 person-rem.

Within the accuracy of the estimates, cumulative worker dose in the Centralization minimum option would not add significantly to the cumulative Hanford Site worker dose over 90 years as described for the No Action Alternative.

5.17 Adverse Environmental Impacts that Cannot be Avoided

Unavoidable adverse impacts that might arise as a result of implementing the alternatives for interim storage of SNF at the Hanford Site are discussed in the following subsections.

5.17.1 No Action Alternative

Adverse impacts associated with the No Action Alternative would derive from the expense and radiation exposure associated with maintaining facilities that are near or at the end of their design life and the possible future degradation of fuel and facilities, thus increasing the potential for releases of materials to the environment.

5.17.2 Decentralization Alternative

Adverse impacts associated with the Decentralization Alternative would derive principally from construction activities needed for new facilities. There would be displacement of some animals from the construction site and the destruction of plant life within the site up to 9 hectares (24 acres). Criteria pollutants, radionuclides, and hazardous chemicals would also be released in up to permitted quantities during processing preparations. Traffic congestion and noise are expected to increase by a few percent during the construction of major facilities. Competition for adequate housing would increase in the already tight market, and capacities at some of the local school would be moderately strained with approximately 0.5 to 1.5 percent additional students, depending on which processing and/or storage option were chosen.

5.17.3 1992/1993 Planning Basis Alternative

Adverse impacts associated with the 1992/1993 Planning Basis Alternative would be essentially the same as those for the Decentralization Alternative. If transport of any amount of SNF were considered an adverse impact, that impact would occur in this alternative if the small amount of TRIGA fuel at Hanford were transported to INEL.

5.17.4 Regionalization Alternative

Unavoidable adverse environmental impacts for the Regionalization Alternative range from those of the Centralization (Minimum) Alternative for Regionalization C where all Hanford SNF is shipped offsite to essentially those of the Centralization (Maximum) Alternative for Regionalization B2 where all SNF west of the Mississippi River including Naval SNF is shipped to Hanford.

5.17.5 Centralization Alternative

In the option where Hanford receives all DOE SNF, adverse impacts would be somewhat larger than those associated with implementing the Decentralization Alternative because about 25 weight percent more fuel than already exists on the Hanford Site would need to be stored; however, higher heat loads on that fuel might nearly triple the capacity needed for storage. Transport of that 25 weight percent of SNF to the Hanford Site also likely would be viewed as an adverse impact.

In the option where Hanford ships all of its fuel to another site, adverse impacts would be associated with construction and operation of a fuel packaging facility. The impacts, however, would be expected to be substantially less than those noted for the Decentralization Alternative. Transporting a relatively large amount of SNF offsite to another DOE facility also likely would be considered an adverse impact.

5.18 Relationship Between Short-Term Uses of the Environment and the Maintenance and Enhancement of Long-Term Productivity

SNF storage is contemplated for up to 40 years pending decisions on ultimate disposition. SNF is essentially uranium-238 with varying amounts of uranium-235 and small amounts of plutonium contaminated by small masses of fission products (but high activity). Because of this composition, a decision could be made at the end of the planned storage period to either continue storage until the energy resource value of the SNF warrants processing for power-reactor fuel or to determine that the fuel will never have any resource value and will be disposed of. If the decision is to continue to store the SNF, that option could be seen as the best use of land at the Hanford Site in terms of long-term productivity. This conclusion would apply to all of the alternatives except for the Regionalization C Alternative and the Centralization Alternative with storage at other than Hanford.

If the decision is to dispose of the SNF or if the non-Hanford centralization option for storage is selected, the land on the Hanford Site would become available for other uses. Because of the potential for, or perception of, contamination, use of the land for agriculture might not be appropriate. Moreover, the land occupied (or that would be occupied) by SNF facilities was of marginal utility for farming before it was obtained for the Hanford Site, and it remains so. However, other uses, such as for wildlife refuges, might be appropriate long-term uses of land vacated by SNF facilities after decommissioning is completed.

5.19 Irreversible and Irretrievable Commitment of Resources

This section addresses the irretrievable commitment of resources that would likely be used to implement the proposed project or its alternatives. An irretrievable resource is a natural or physical resource that is irreplaceably lost and cannot be replenished.

Implementation of the proposed project would result in the irretrievable use of fossil fuels in construction activities and in the transport of raw materials to the project site. In addition, there would be an irretrievable use of electricity and fossil fuel in the SNF operations. Briefly summarized below are discussions of irretrievable and irreversible resource impacts for each alternative.

5.19.1 No Action Alternative

The irreversible and irretrievable commitment of resources for the No Action Alternative would include an additional increment of energy, materials, and manpower to maintain safe and secure facilities. A new SNF facility would not be built, and Hanford SNF would continue to be managed in the current mode.

If the No Action Alternative were implemented, the following facilities would likely be used at the Hanford Site to maintain continued safe and secure storage of SNF: the 105-KE and KW Basins, FFTF, T-Plant, and the 308, 324, 325, and 327 buildings. Excluding energy and materials expended during construction of minor facilities to maintain safety and security, the operational staff is estimated at 215 personnel, and electrical power consumption is estimated to be 12,000 megawatt hours per year. This alternative represents less than a 2 percent increase in existing personnel at the Hanford Site and a negligible increase in the total amount of electrical energy currently used at the Hanford Site.

5.19.2 Decentralization Alternative

The irreversible and irretrievable commitment of resources for the Decentralization Alternative would include an additional increment of energy, materials, and personnel. Existing Hanford Site SNF would be safely stored for a 40-year period, with some limited SNF shipments. To accommodate this mission, existing facilities would require upgrading and new storage systems would need to be constructed. Various options have been proposed on which facilities to build and how to upgrade existing ones, but it has not been determined exactly which kind of facilities would need to be built. A representative set of values is presented in Table 5.19-1, which roughly indicates the material, personnel, and energy commitments. Depending on the option chosen, the alternative could require less than a 1.5 percent increase or up to a 33 percent increase (but only for 4 years) in the total amount of electrical energy currently used at the Hanford Site.

In addition to energy increases, additional water resources would be required for this alternative, but are not expected to be an excessive amount, compared to the more than 15 million cubic meters (4 billion gallons) of water used each year on the Hanford Site for all processes.

Table 5.19-1. Irretrievable commitment of materials in the Decentralization Alternative suboptions.

Item	Suboption					
	W	X	Y	Z	P	Q
Concrete,	13 (17)	15 (20)	17	24 (32)	22 (29)	29 (38)

thousand cubic meters/(cubic yards)			(23)			
Lumber, thousand cubic meters (board feet)	1.2 (500)	1.4 (570)	1.6 (650)	2.2 (930)	2.0 (850)	2.6 (1100)
Electricity						
Construction (MW--hrs)	2500	2900	3500	4800	4370	5700
Operations (MW-hrs/yr)	1600	1600	100	100	40,000	127,000
Diesel fuel, cubic meters (thousand gallons)	500 (130)	570 (150)	660 (175)	900 (240)	830 (220)	1100 (290)
Gasoline, cubic meters (thousand gallons)	500 (130)	570 (150)	660 (175)	900 (240)	830 (220)	1100 (290)

a. Assumes operation of the process facility (28,000 or 115,000 MW-Hrs/yr) concurrently with those facilities where SNF is currently stored (12,000 MW-Hrs/yr, as in the No Action Alternative) for an interim period less than 4 years.

5.19.3 1992/1993 Planning Basis Alternative

The irreversible and irretrievable commitment of resources for the 1992/1993 Planning Basis Alternative would be very similar to those for the Decentralization Alternative. The materials, personnel, and energy estimates are assumed to approximate those stated in the Decentralization Alternative.

5.19.4 Regionalization Alternative

The Regionalization Alternative as it applies to the Hanford Site contains the following options:

- Option A - All SNF except defense production SNF would be sent to INEL.
- Option B1 - All SNF west of the Mississippi River except Naval SNF would be sent to Hanford.
- Option B2 - All SNF west of the Mississippi River and Naval SNF would be sent to Hanford.
- Option C - All Hanford SNF would be sent to INEL or NTS.

With the exception of Option C, which for Hanford is equivalent to the Centralization Alternative minimum option, the irretrievable and irreversible commitment of material resources are provided in Tables 5.19-2 through 5.19-4.

5.19.5 Centralization Alternative

The Centralization Alternative has two major options: either all Hanford SNF would be shipped offsite to another DOE facility where all SNF would be centralized (minimum option), or the Hanford Site would become the centralized location for all DOE SNF to be temporarily

Table 5.19-2. Irretrievable commitment of material resources in the Regionalization A suboptions.

Item	Suboption W	X	Y	Z	P	Q
Concrete, thousand cubic meters/(cubic yards)	9 (12)	9 (12)	16 (21)	19 (25)	22 (29)	29 (38)

Lumber, thousand cubic meters (board feet)	0.8 (350)	0.8 (350)	1.4 (600)	1.7 (700)	2.0 (850)	2.6 (1100)
Electricity						
Construction (MW-hrs)	1800	1800	3200	3800	4370	5700
Operations (MW-hrs/yr)	1600	1600	100	100	40,000a	127,000a
Diesel fuel, cubic meters (thousand gallons)	380 (100)	380 (100)	610 (160)	720 (190)	830 (220)	1100 (290)
Gasoline, cubic meters (thousand gallons)	380 (100)	380 (100)	610 (160)	720 (190)	830 (220)	1100 (290)

a. Assumes operation of the process facility (28,000 or 115,000 MW-Hrs/yr) concurrently with those facilities where SNF is currently stored (12,000 MW-Hrs/yr, as in the No Action Alternative) for an interim period less than 4 years.

Table 5.19-3. Irretrievable commitment of material resources in the Regionalization B1 option.
(In addition to those listed for the Decentralization Alternative)

Concrete, thousand cubic meters/(cubic yards)	54 (70)
Lumber, thousand cubic meters (board feet)	5 (2,000)
Electricity, megawatt hours per year	3.000
Diesel fuel, cubic meters (thousand gallons)	1,900 (500)
Gasoline, cubic meters (thousand gallons)	1,900 (500)

Table 5.19-4. Irretrievable commitment of material resources in the Regionalization B2 option.
(In addition to those listed for the Decentralization Alternative)

Concrete, thousand cubic meters/(cubic yards)	120 (150)
Lumber, thousand cubic meters (board feet)	10 (4,200)
Electricity, megawatt hours per year	3,000
Diesel fuel, cubic meters (thousand gallons)	4,400 (1,200)
Gasoline, cubic meters (thousand gallons)	4,400 (1,200)

stored (maximum option). The increases in energy, materials, and personnel for both options are shown in Table 5.19-5. If all the SNF were shipped to the Hanford Site, then the impacts would be similar, although somewhat larger, than those of the Regionalization B options. If all the SNF were shipped offsite, then the impacts would be identical to the similar Regionalization B options. If all SNF were shipped offsite, construction and operation of a fuel packaging facility would be necessary before shipments could be made to an offsite facility.

5.20 Potential Mitigation Measures

This section summarizes possible mitigation measures that might be considered to avoid or reduce impacts to the environment as a result of Hanford Site operations in support of SNF management. These measures would be reviewed and revised as appropriate, depending on the specific actions to be taken at a facility, the level of impact, and other pertinent factors.

Table 5.19-5. Irretrievable commitment of materials in the Centralization options.

Item	No Fuel Stored at the Hanford Site	All Offsite Fuel Stored at the Hanford Site
Concrete, thousand cubic meters (cubic yards)	18 (23)	150 (200)
Lumber, thousand cubic meters (board feet)	1.6 (660)	13 (5600)
Electricity, megawatt hours per year	0-20,000	100-127,000
Diesel fuel, cubic meters (thousand gallons)	640 (170)	5700 (1500)
Gasoline, cubic meters (thousand gallons)	640 (170)	5700 (1500)

Possible mitigation measures are generally the same for all alternatives and are summarized by resource category below. No impacts on land use and aesthetic and scenic resources were identified; therefore, mitigation measures would not be necessary.

5.20.1 Pollution Prevention/Waste Minimization

The U.S. Department of Energy is responding to Executive Order 12856 and associated DOE orders and guidelines by reducing the use of toxic chemicals; improving emergency planning, response, and accident notification; and encouraging the development and use of clean technologies and the testing of innovative pollution prevention technologies. Program components include waste minimization, source reduction and recycling, and procurement practices that preferentially procure products made from recycled materials. The pollution prevention program at the Hanford Site is formalized in a Hanford Site Waste Minimization and Pollution Prevention Awareness Program Plan.

The SNF program activities would be conducted in accordance with this plan and implementation of the pollution prevention and waste minimization plans would minimize the generation of waste during SNF management activities.

5.20.2 Socioeconomics

The level of predicted employment for SNF activities at the Hanford Site is not large enough in comparison with present Hanford, local, or regional employment to produce a boom-bust impact on the economy.

5.20.3 Cultural (Archaeological, Historical, and Cultural) Resources

To avoid loss of cultural resources during construction of SNF facilities on the Hanford Site a cultural resources survey of the area of interest would be conducted by PNL Cultural Resources staff. Assuming no such resources were found, construction would proceed. If, however, during construction (earth moving) any cultural resource is discovered, construction activities would be halted and the PNL Cultural resources staff called upon to evaluate and determine the appropriate disposition of the find.

To avoid loss of cultural resources during operation, such as unauthorized artifact collection, workers could be educated through programs and briefing sessions to inform them of applicable laws and regulations for site protection. These educational programs would stress the importance of preserving cultural resources and specifics of the laws and regulations for site protection. The exact location of cultural resources are not identified by the PNL Cultural Resources group; therefore, any such artifact collection would be in an area discovered by the worker(s).

5.20.4 Geology

Soil loss would be controlled during construction using standard dust suppression techniques on disturbed soil and by stockpiling with cover where necessary. Following construction, soil loss would be controlled by revegetation and relandscaping of disturbed areas. Any soil that might become contaminated as a result of SNF management activities could be remediated using methods appropriate to the type and extent of contamination.

5.20.5 Air Resources

To avoid impacts associated with emissions of fugitive dust during construction activities, exposed soils would be treated using standard dust suppression techniques. New facility sources of pollutant emissions to the atmosphere would be designed using best available technology to reduce emissions to as low as reasonably achievable.

5.20.6 Water Resources

The impacts to surface and groundwater sources could be minimized through recycling of water, where feasible, and with clean-up of excess process water before release to ground or surface water.

5.20.7 Ecology

To avoid impacts to endangered, candidate, or state-identified sensitive species, pre-construction surveys would be completed to determine the presence of these species or their habitat. Within six months of ground breaking, DOE would again consult with the U.S. Fish and Wildlife Service to determine current species listings and perform a biological survey of the proposed SNF site. The presently proposed site at Hanford has been surveyed and no currently listed species were found. While not endangered, stands of Big Sagebrush habitat are diminishing generally and Hanford would expect to implement its habitat replacement program to provide areas on at least a 2 to 1 basis to mitigate habitat loss. In addition, areas disturbed would, as appropriate, be seeded with native plant species.

5.20.8 Noise

Generation of construction and operations noise would be reduced, as practicable, by using equipment that complies with EPA noise guidelines (40 CFR Parts 201-211). Construction workers and other personnel working in environments exceeding EPA-recommended guidelines during SNF storage construction or operation would be provided with earmuffs or earplugs approved by the Occupational Safety and Health Administration (29 CFR Part 1910). Because of the remote location of the Hanford SNF activities, there would be no noise impacts with respect to the public for which mitigation would be necessary.

5.20.9 Traffic and Transportation

At sites with increasing traffic concerns, DOE could encourage use of high-occupancy vehicles (such as vans or buses), implementing carpooling and ride-sharing programs, and staggering workhours to reduce peak traffic.

5.20.10 Occupational and Public Health and Safety

Although no radiological impacts on workers or the public were evident from the evaluation of routine SNF activities at Hanford, further improvement in controls to protect both workers and the general public is a continuing activity. The as low as reasonably achievable (ALARA) principle would be used for controlling radiation exposure and exposure to hazardous/toxic substances. Hanford would continue to refine its current emergency planning, emergency preparedness, and emergency response programs in place to protect both workers and the public.

5.20.11 Site Utilities and Support Services

No mitigation measures beyond those identified for ground disturbance activities associated with bringing power and water to the SNF site would appear necessary. In those cases use of standard dust suppression techniques and revegetation of disturbed areas would mitigate ground disturbance impacts.

5.20.12 Accidents

The Hanford Site maintains an emergency response center and has emergency action plans and equipment to respond to accidents and other emergencies. These plans include training of workers, local emergency response agencies (such as fire departments) and the public communication systems and protocols, readiness drills, and mutual aid agreements. The plans would be updated to include consideration of new SNF facilities and activities. Design of new facilities to current seismic and other facility protection standards would reduce the potential for accidents, and implementation of emergency response plans would substantially mitigate the potential for impacts in the event of an accident.

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8. ACRONYMS AND ABBREVIATIONS

ALARA	as low as reasonably achievable
ANL	Argonne National Laboratory
ARMF	advanced reactivity measurement facility
ATM	approved testing materials
ATRC	advanced test reactor canal
BWR	boiling water reactor
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CFRMF	coupled fast reactivity measurement facility
DCG	Derived Concentration Guides
DFA	driver fuel assemblies
DOE	U.S. Department of Energy
EA	environmental assessment
ECF	Expended Core Facility
ElS	environmental impact statement
EPA	Environmental Protection Agency
EPCRA	Community Right-to-Know-Act
ERPG	Emergency Response Planning Guideline
ER&WM	environmental restoration and waste management
FAST	Flourinel and Storage Facility at INEL
FECF	fuel element cutting facility
FFTF	Fast Flux Test Facility
FSF	fuel storage facility
FSF	Underwater Fuel Storage Facility (located at INEL)
HLW	high-level waste
IDF	Inspection dose factor
IDLF	Immediately Dangerous to Life and Health Values

IDS	interim decay storage
IDLH	Immediately Dangerous to Life and Health Values
IEM	interim examination and maintenance
INEL	Idaho National Engineering Laboratory
IVS	in-vessel storage
ILCF	latent cancer fatalities
LLW	low-level waste
MEPAS	Multimedia Environmental Pollutant Assessment System
MT	metric tons
MTHM	metric tons of heavy metal
MTR	materials test reactor
MTU	metric tons of uranium
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NRF	Naval Reactors Facility
NRHP	National Register of Historic Places
NTS	Nevada Test Site
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Safety and Health Administration
PBF Canal	power burst facility canal
PEIS	programmatic environmental impact statement
PFP	Plutonium Finishing Plant
PSD	Prevention of Significant Deterioration
PUREX	Plutonium and Uranium Recoverv thrnii~ PYt~~~~
PWR	pressurized water reactor
RH-TRU	remote-handled transuranic material
RTEC	Registry of toxic effects for chemical substances
SBA	standard blanket assemblies
SHPO	Washington State Historic Preservation Officer
SNF	spent nuclear fuel
SPR	single-pass reactor
SRS	Savannah River Site
SS	single-shell tank
TDFA	test driver fuel assemblies
TEDF	Treated Effluent Disposal Facility
TFA	test fuel assemblies
TLV/TWA	Threshold Limit Values/Time Weighted Averages
TRIGA	Training, research, and isotope reactors built by General Atomic
WAC	Washington Administrative Code
WIPP	Waste Isolation Pilot Plant

ATTACHMENT A

FACILITY ACCIDENTS

Methods used to evaluate facility accidents associated with implementing the alternatives for SNF storage at Hanford are discussed in this attachment. The selection of radiological accidents for the analysis was based on information available in previously published safety or National Environmental Policy Act documents, as described in Section 5. 15. Analyzed releases of nonradiological hazardous materials were based on actual or expected inventories at SNF management facilities using conservative release assumptions. Industrial construction and operational accidents are also evaluated based on the person-years needed to build and operate SNF facilities.

A.1 Radiological Accidents

The GENII computer code (Napier et a!. 1988) was used to perform calculations for each facility to estimate the consequences of radionuclide releases to the atmosphere for onsite workers, members of the public at accessible locations on or near the site, individual residents at the site boundary, and the population within 80 km of the release location. Dose calculations used standard assumptions for the Hanford Site (Schreckhise et a!. 1993), and health effects were estimated using recommendations of the International Commission on Radiological Protection in its Publication 60 (ICRP 1991). The risks of cancer and other long-term stochastic health effects as estimated by ICRP (1991) are based on populations exposed to relatively high doses of radiation at high dose rates. For estimating risk to populations where the total doses are below 20 rad, the ICRP recommended a low-dose reduction factor equal to 2. In this analysis, where accidents would yield individual dose estimates greater than 20 rad, the ICRP risk factors are used without the low dose correction to obtain the potential health effects.

Individual doses were estimated based on exposure of the receptor during the entire release, except where the release was sufficiently tong that it could be divided into short-term and long-term components. In that case, onsite workers and members of the public at accessible onsite locations were assumed to remain in the path of the plume for the duration of the short-term component. The exposure duration for onsite individuals was assumed to be two hours, corresponding to the maximum time required to evacuate the Hanford Site in the event of an accident, and no ingestion pathways were considered. Offsite individuals were assumed to be exposed during the entire release, regardless of the accident duration. Because protective action guidelines specify mitigative actions to prevent consumption of contaminated food, the dose to offsite individuals and populations was estimated both with and without the food ingestion pathways. Reduced exposure to the plume or to contaminated ground surface as a result of early evacuation of offsite populations was not considered for the purposes of this analysis, although such action would certainly be taken in the event of a severe accident at the site.

Individual dose calculations were performed using atmospheric dispersion parameters that represented 95 percent conditions (i.e., the air concentrations used would not be exceeded more than S percent of the time). In the case of collective dose, the area surrounding the source was divided into 16 directions and 10 sectors by distance, and the dose was calculated for only the direction resulting in maximum collective exposure. Dose to the population was calculated using both 50 percent and 95 percent atmospheric dispersion parameters.

A.1.1 No Action Alternative

The No Action Alternative consists of fuel storage at existing Hanford facilities, including the 100-K Area wet storage basins; T Plant and a low-level burial ground in the 200-West Area; the 308, 324, 325, and 327 buildings in the 300 Area; and the Fast Flux Test Facility in the 400 Area. Maximum reasonably foreseeable accidents determined by Previously published analyses were used for this evaluation, and the impacts of these accidents were reevaluated using a consistent set of parameters for the spectrum of receptors required for this document.

A.1.1.1 105-KE and 105-KW Basin Wet Storage. Airborne releases from the fuel

storage pool are bounded by a postulated accident for the 105-ICE and l05-KW Basins. In the accident, a cask is dropped and overturned in the fuel transfer area, with broken fuel elements spilling out of the cask, within the pool building, but away from the pool. The scenario assumes that the shipping cask ruptures, exposing all of the broken fuel elements in three canisters: 42 fuel elements each containing 22.5 kilograms (50 pounds) of fuel. The probability of this accident is estimated as 10(-4) to 10(-6) per year. The analysis assumes lO-year-old fuel-grade fuel (12 percent of plutonium content is Plutonium.240). The source term is calculated by multiplying the inventory at risk by the release fraction. The calculation of the release fractions assumes the fuel heats but does not melt. Also, site evacuation is assumed, giving a two-hour time for calculation of the onsite release factor. The offsite release factor was calculated using an eight-hour release time. The calculated release quantity was 61 grams (0.14 pounds) for onsite exposure and 244 grams (0.54 pounds) for offsite exposure, resulting in the radionuclide releases listed in Table A-1. Recalculation of the doses for this analysis yields the results in Table A-2.

Table A-1. Estimated radionuclide releases for a dropped fuel casket accident in the 105-K wet storage basins.

Table A-2. Consequences of 105-KE Basin cask drop accident.

A cask drop involving broken fuel elements falling out of the cask would most likely be observed by the workers, who would also be alerted by area radiation alarms and the radiation monitor in attendance of a change in radiation intensity. The assumed 12 workers would likely be in Special Work Permit protective clothing, but typically would not be wearing respiratory protection. The workers would immediately evacuate the area to reduce their exposure to direct radiation (by increasing their distance from the source), for which their clothing provides no protection. Once at a distance, they would move upwind of the postulated airborne release before beginning decontamination procedures. Assuming the workers evacuate within 1 to 2 minutes, their dose would range from about 70 to 140 rem. Using risk factors cited previously, the maximum probability of an individual contracting a fatal cancer from a dose of 140 rem would amount to about 0.06. The collective worker dose for such a scenario would amount to about 1800 person-rem for which one fatal cancer would be inferred. It should be noted, however, the risk factors used are not generally intended to be applied to large acute doses and such acute doses might produce minor near term adverse health effects.

Recent preliminary analyses, based on updated information on the ability of the lOS-K Basins to withstand natural forces indicate that seismic-induced damage at the 105-K Basins could, under some circumstances, result in radiation exposure to the public and workers greater than that indicated in this EIS. The underlying concern is whether the fuel in its present condition could become uncovered by loss of the basin water thereby resulting in larger releases of radionuclides to the atmosphere; in the present analysis the fuel is assumed to remain covered. A scenario in which the fuel would remain exposed to the air and allowed to burn is not considered a reasonably foreseeable accident for the time period covered by this EIS.

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a. cute doses of this magnitude are in the lower end of the range of doses that might produce symptoms of acute radiation syndrome in humans.

A.1.1.2 Liquid Release Scenario for 105-KE or 105-KW Basin. Accidental liquid releases from the 105-K Basins are bounded by seismic events or other mechanical disruption of the basin or its water supply system. The most probable scenario is a break in an 8-inch water supply line that overfills the storage pool causing water to overflow onto the surrounding soil (Bergsman 1995). The flow is assumed to continue for 8 hours before the supply is shut off, resulting in release of 2300 cubic meters (600,000 gallons) of water and 60% of the radionuclide inventory m the pool water. The inventory released from the 105-ICE Basin is assumed to be 13 Ci tritium, 0.029 Ci cobalt-60, 9.2 Ci strontium-90, 0.042 Ci cesium-134, 12 Ci cesium-l37/barium-137m, 0.0098 Ci plutonium-238, and 0.056 Ci plutonium-239.

The corresponding radionuclide inventory m the 105-KW Basin overflow pond is assumed to be as follows: 0.48 Ci tritium, 0.0013 Ci cobalt-60, 0.0031 Ci cesium-134, 0.22 Ci cesium-137, 1.1 Ci strontium-90, 5.9E-06 Ci plutonium-238, and 3.lE-05 Ci plutonium-239. The overflow is assumed to leach through the subsurface environment to the Columbia River. Because the transmission rate of the soil is estimated as 570 centimeters per day [based on DOE's Programmatic Environmental Impact Statement (PEIS) (Schramke 1993)], a leaching rate of 26.3 centimeters per day (10 inches per day) will not result in a ponded situation; therefore, the entire 2300 cubic meters (600,000 gal) of overflow will leach into the soil over an eight-hour period. Contaminants are assumed to travel through the vadose zone, through the saturated zone to the Columbia River and in the Columbia River to receptors downstream. The flow discharge in the Columbia River is assumed to be under low-flow conditions of 1000 cubic meters per second (36,000 cubic feet per second) (Whelan et al. 1987), which represents the most conservative case for maximizing surface water concentrations. As a conservative assumption, the removal of water from the Columbia River is assumed to be 100 meters (328 feet) downstream of the point of entry of the contaminant into the river. The assessment addressed recreational activities (e.g., boating, swimming, fishing) in the Columbia River and use of the water as a drinking-water supply and for bathing, irrigation, etc. The collective risk of fatal cancer from the spill at the 105-KW Basin was estimated as approximately 1.1 x 10.13 fatal cancers for the maxiinum pathway and radionuclide (ingestion of plutonium-239 in fish) at 2800 years. The cumulative risk from all radionuclides and pathways amounted to approximately 6 x 10(-13) fatal cancers. The corresponding risks from a spill at the 105-KE Basin were 2 x 10(-10) fatal cancers for the maximum nuclide and pathway (also from ingestion of plutonium-239 in fish), and about 6 x 10.10 fatal cancers for all radionuclides and pathways (Whelan et al. 1994).

The overflow scenario described in the previous paragraph has been extrapolated to include a larger release because of recent concerns about the effects of a seismic event severe enough to breach joints in the basin. A crack in the basin would potentially release all of the basin water and perhaps some of the sludge to the subsurface environment, where it would be available for leaching to groundwater and transport to the Columbia River. Because the liquid overflow scenario assumes release of over half of the basin water, the risk to a downstream individual from release of all the basin water would be less that twice that estimated for the overflow scenario. Radionuclides in the sludge would be much less mobile and would leach into groundwater slowly, providing time for remediation and mitigation measures as necessary. Even if significant quantities of sludge remained in the subsurface soil for an extended period prior to clean up, the risk to the downstream individuals and population would not likely be substantially higher than that estimated for the overflow scenario.

This accident would not likely present any hazard to workers at the basin because the scenario is liquid to ground to groundwater and on to the Columbia River and does not involve a source of exposure to the close-in workers.

A.1.1.3 308 Building. The maximum reasonably foreseeable accident for airborne

releases related to fuel storage at the 308 Euilding is dropping a transfer basket while moving fuel from the reactor core to the storage pool (WHC 1990). It was conservatively estimated that 13 fuel elements would have their cladding damaged, resulting in the release of 100 percent of the krypton-85 to the environment in S minutes. The probability of this accident is estimated as l0(-2) to 10(-4) per year. In the Original Safety Analysis Report, the resulting dose was estimated at 0.013 rem to the worker, 8.6 x l0(-4) rem to the onsite individual, and 8.6 x lO(-5) rem at the Site boundary. Collective dose to the population was not reported in the SAR. The individual doses correspond to a probability of fatal cancer of 5.2E-06 per year for the worker, 4.3E-07 per year for the onsite member of the public, and 4.3E-08 per year at the site boundary.

This information is provided in more detail in WHC (1990), which, however, does not detail the total quantity of krypton-85 released in any of its accident scenarios. Because release quantities for krypton-85 were not available, the consequences of this accident were not re-evaluated for this analysis. Note that the SAR worker evaluation is for an individual in the facility who is assumed to evacuate within S minutes. This is a somewhat different analysis from those for the other worker consequences presented for the Hanford Site, which assume a worker remains outside the facility at the point of maximum air concentration for a period of up to 2 hours.

A transfer basket drop that results in damage to 13 fuel elements would most likely be observed by the workers, who would also be alerted by area radiation alarms and the radiation monitor in attendance of a change in radiation intensity. The assumed 12 workers would likely be in Special Work Permit protective clothing, but typically would not be wearing respiratory protection. The workers would immediately evacuate the area to reduce their exposure to direct radiation (by increasing their distance from the source), for which their clothing provides no protection. Once at a distance, they would move upwind of the postulated airborne release before beginning decontamination procedures. It was estimated (WHC 1990) that the workers would receive a dose of 13 millirem. The collective worker dose would amount to about 0.2 person-rem, and no latent cancer fatalities would be predicted for these workers.

A.1.1.4 324 Building. The greatest potential safety concern at the 324 Building comes

from a safety assessment of the current levels of potentially highly mobile radioactive material in B-Cell (PNL 1992a). The potential failure of the 324 Building exhaust ventilation system in a 0.1 g seismic event, along with shaking of highly mobile holdup material in the 324 Building hot cells, could cause a total release of 610 Ci of cesium- 137 and 310 Ci of strontium-90 within 12 hours. Of this total, approximately 55 percent (340 Ci of cesium-137 and 170 Ci of strontium-90) would be released in the first two hours. The probability of the initiating seismic event is 4 x 10A per year, and the other events leading to the release are assumed in this analysis to occur with certainty. The consequences of this accident are presented in Table A-3. In comparison to this accident, other potential releases from the building are judged to be insignificant, or they have been determined to be less probable because of radioactive material containment or handling frequency. The consequences associated with this accident are a result of existing contamination in the 324 Building hot cells, and neither its likelihood nor its severity depend on the presence of spent fuel in the facility. The actual contribution of spent fuel to releases from the accident is assumed to be negligible compared with that of other sources.

A seismic event that causes the failure of the 324 Building exhaust ventilation system and releases significant quantities of non-spent nuclear fuel-related radioactive materials from the building could occur at any time, whether or not there were workers in the building. An earthquake of sufficient intensity to cause the ventilation failure would surely be noticed by any workers in the building. In all likelihood, area radiation alarms would also sound. The assumed 50 workers would immediately evacuate the building and move to a position upwind of the building. Although speculative, the workers might receive as much as 25 rem before reaching a completely safe zone. If that were the case, they would probably be restricted from further radiation worker pending results of reading their dosimeters and completion of a medical evaluation. The maximum probability of an individual contracting a fatal cancer from such a dose would amount to about 0.02. The postulated collective dose would amount to about 1300 person-rem, from which one latent cancer fatality might be inferred. Based only on the estimated initiating earthquake frequency, the chances of these consequences occurring would be about 1 in 5,000 per year.

Table A-3. Consequences of a seismic event at the 324 Building.

A.1.1.5 325 Building. A severe earthquake, without subsequent fire, is the maximum

reasonably foreseeable accident for the 325 Building (PNL 1992b). It is postulated that an earthquake would cause windows to break but not cause general or local structural collapse. Doors may be jammed open after building evacuation, leaving additional openings for unfiltered releases. Building power or ventilation could be lost. Further damage would be caused to glove boxes and the contents of shelves and cabinets. The expected effects are considered to be the most severe that could result from a 0.135 g horizontal acceleration, corresponding to the

2 x 10(-4)per year seismic event for which protection is required by DOE design criteria for a new structure.

Radionuclide releases associated with this accident are listed in Table A-4. It should be noted that the environmental releases associated with the earthquake scenario are from all sources in the 325 Building; fuel storage activities account for only a small fraction of the total. Because these releases consist of a variety of chemical forms, the dose factors used for calculation of the consequences represented the maximum dose for all radionuclides in the total release. The consequences of this accident are presented in Table A-5.

An earthquake that results in openings for unfiltered releases from the 325 Building releasing significant quantities of non-spent nuclear fuel-related radioactive materials could occur at any time, whether or not there were workers in the building. An earthquake of sufficient intensity to cause damage to the ventilation system and possibly glove boxes and windows would surely be noticed by any workers in the building. Whether area radiation monitors alarmed or not, the assumed 50 workers would immediately evacuate the building and, once outside, would move to a position upwind of the building. Although speculative, the workers might receive as much as 3 rem before reaching a completely safe zone. The maximum probability of latent fatal cancer for such a dose would be 0.001. The postulated collective dose would amount to about 150 person-rem, from which no latent cancer fatalities would be inferred.

A.1.1.6 327 Building. The postulated maximum reasonably foreseeable accident for

fuel storage at the 327 Building consists of mechanical damage to fuel pins and subsequent fire involving reactive fuel within a hot cell (WHC 1987). Because of the variety of activities that can occur in the hot cells, specific details of the accident were not postulated. The mechanical damage would breach the pin cladding and immediately release the gaseous fission products in the fuel-cladding gap. The subsequent fire would cause complete reaction of reactive fuel forms.

Table A-4. Radionuclide releases for the 325 Building earthquake scenario. Table A-5. Consequences of a seismic event at the 325 Building.

Fission products are released to the environment through the ventilation system, which includes HEPA and activated charcoal filtration. The frequency of this accident is estimated as 10(-4) to lO(-6) per year. The hot cell inventory and the fraction of the inventory released are shown in Table A-6.

The previous analysis evaluated the most extreme case for damaged material containing the maximum aflowable limits of fission products that had not been vented to release fission gases. In this case, fuel materials involved are assumed to be nonreactive in water and to contain a maximum fission product inventory of 6.5 x 106 Ci including 2500 Ci of halogens. Radionuclide releases from the fuel into the basin water and thence into the air above the water are based on U.S. Nuclear Regulatory Commission Regulatory Guide 1.25, which addresses accidents involving spent fuel in a storage pool. The consequences of the accident as evaluated for this document are listed in Table A-7.

Table A-6. Assumed inventories and release fractions for a 327 Building hot cell fire. Table A-7. Consequences of 327 Building hot cell fire.

This accident involves mechanical damage to fuel pins, subsequent fire within a hot cell, and releases of radioactive material to the intact filtered ventilation system and on to the atmosphere. There would be no added source of radiation exposure to the close-in worker at the hot cell.

A.7.1.7 200-West Area Low-Levei Waste Btirial Grounds. The only accident

postulated to have any significant radiological releases in the Burial Ground safety analysis report is briefly described as a vehicle impact on one or more EBR II casks followed by a fire (Saito 1992). Two vehicle impact scenarios were discussed in the document:

1. Severe impact or collision followed by a short-duration fire caused by a vehicular accident in the trench.
2. Extremely severe impact or collision followed by a long duration fire.

The consequences of the latter accident were evaluated for fuels containing maitmum inventories of either fission product or transuranic radionuclides. The probability of the accident is estimated to be 9.8 x 10-6 per year. The consequences of the less severe accident would be approximately an order of magnitude lower. The radionuclide releases for accident scenario 2 are shown in Table A-8; the accident consequences as re-evaluated for this document are presented in Table A-9. The maximum fission product inventory fuel yielded the highest consequences for offsite receptors where the ingestion pathway was considered. The maximum transuranic inventory was associated with higher consequences for the inhalation and external exposure pathways.

Table A-8. Radionuclide releases for spent nuclear fuel storage at 200-West Burial Ground, accident scenario 2- extremely severe impact with long duration fire.

The severe impact or collision followed by fire as postulated here might have serious-to-fatal nonradiological consequences to drivers and passengers of the vehicles involved. It is assumed that two drivers and two passengers are involved, These individuals would evacuate the area, if they were able. Because it cannot be assured that after the collision either drivers

Table A-9. Consequences of the cask impact accident and fire at 200-West Burial Ground.

or passengers would be able to evacuate the area to a safe distance from radiological consequences, the worst case is assumed, that the four individuals perish in this accident principally from trauma caused by the collision and fire. The likelihood of these consequences occurring are estimated at 1 chance in 100,000 per year.

A.1.1.8 T Plant. The maximum scenario for fuel storage at T Plant is a dropped fuel

assembly inside the building (Jackson and Hanson 1978). The probability associated with this accident is estimated to be 2.8 x 10(-3) per year. The release estimates assume damage to a fraction of the wafers in the dropped fuel module containing 4-year-cooled Shippingport PWR Core II fuel (a conservative assumption because the fuel has now been cooled for approximately 20 years). Other release assumptions include the following:

- 10% of nonvolatile radionuclides in broken fuel are released to the building floor
- 0.1% of the released particulate matenal is resuspended in the building
- All of the volatile krypton-85 is released to the building atmosphere
- Building filtration removed 98.6 percent of the particulate materials from the effluent exiting the stack.

Release estimates for this scenario are presented in Table A-10 and the consequences of the release are listed in Table A-11.

Because workers evacuate the canyon area when fuel assemblies are being moved to or from the casks or pool, there would be no opportunity for impacts on workers from a dropped fuel assembly in fuel storage at T Plant.

Table A-10. Releases for damaged assembly of Shippingport Core II fuel with 4-year decay at T Plant.

Table A-11. Consequences of fuel assembly damage at T Plant. A.1.1.9 Fast Flux Test Facillty (FFTF). The accident scenario for the handling and storage of irradiated FFTF fuel in the Fuel Storage Facility (FSF) is a liquid metal fire (Gantt 1989). The accident scenario is a spill of 11,793 kg of liquid sodium and subsequent fire. The spill is initiated by either an internal event or a seismic event that causes a break in the piping between the FSF and heat exchangers. The liquid sodium is assumed to ignite spontaneously and burn, releasing aerosols to the atmosphere. The probability of this accident is estimated to be 10(-4) to 10(-6) per year.

The radionuclide release is from cesium that has been leached from the fuel into the sodium. It is assumed for this accident that 0.1 percent of the elements are breached and that the sodium contains 0.9 uCi cesium- 134 per gram of sodium and 5 uCi cesium-137 per gram of sodium. It is assumed that 35 percent of the sodium and cesium aerosols generated in the fire are released to the atmosphere. The total activity released is estimated as 3.7 Ci cesium- 134 and 25 Ci cesium-137. The consequences of the accident as estimated are listed in Table A-12. Onsite individuals (workers and members of the public at onsite access locations) were assumed to be exposed during 0.4 percent of the total release, because the spilled sodium would require over 20 days to burn completely, and onsite individuals were assumed to be evacuated within 2 hours.

Table A-12. Consequences of liquid metal fire at the Fast Flux Test Facility. An internal event or a seismic event that causes a break in the piping between the FSF and heat exchangers could occur whether workers were present or not. The event would surely be noticed by any workers in the building. In all likelihood, area radiation alarms would also sound. The assumed 50 workers would immediately evacuate the building and, once outside, would move to a position upwind of the building. Because this is an accident that involves a slow release of material to the atmosphere, it is speculated that dose to the close-in workers would not exceed 0.1 rem from this accident. The postulated collective dose would amount to about 5 person-rem, from which no latent cancer fatalities would be expected.

A.1.2 Decentralization Alternative

The Decentralization Alternative involves construction of several new facilities at Hanford, including new dry storage for spent fuel or a combination of new wet and dry storage. Options are also included for several types of fuel processing prior to storage. The consequences of new facilities are based on previously evaluated accidents for similar installations, adapted for the conditions and location of these facilities as assumed in this analysis.

A.1.2.1 New Wet Storage. This accident scenario is the same as that described for a

dropped fuel container at the 100-K Basins. The releases are assumed to be the same as for the accident previously described (see Table A-1), but the evaluation was repeated for potential location of the new facility adjacent to the 200-East Area. The accident frequency in the No Action Alternative is also assumed for this alternative because the quantity of fuel handled in either case would be the same. The consequences of this accident for a new facility are shown in Table A- 13.

A maximum reasonably foreseeable liquid release scenario has been postulated for the new pool storage facility for wet storage of nuclear fuels. The leak is based on a 20-cm (8-inch) water-supply pipe breaking inside of the pool building and releasing 7600 liters per minute (2000 gallons per minute). The flow is not shut off for 8 hours, resulting in 3600 cubic meters (960,000 gal) being added to the pool. Because the pool cannot handle this amount of liquid, there is an overflow of 2300 cubic meters (600,000 gal) in this 8-hour period. Because the trans-missidn rate of the soil is estimated as 570 centimeters per day (220 inches per day) [based on DOE's Programmatic Environmental Impact Statement (PEIS) (Schramke 1993)], a leaching rate of 26.3 centimeters per day (10 inches per day) will not result in ponding; therefore, the entire volume of overflow will leach into the soil over an 8-hour period. The basin overflow does contain 61 percent of the basin-water radionuclide inventory, which is estimated as 1.8 Ci. The specific radionuclide inventory in the overflow pond is assumed to be as follows: 0.48 Ci tritium, 0.0013 Ci cobalt-60,'0.031 Ci cesium-134, 0.22 Ci cesium-137, 1.1 Ci strontium-90, 5.9E-06 Ci plutonium-238, and 3.lE-05 Ci plutonium-239. All of the constituents in this assessment are radionuclides. Contaminant migration is through the vadose zone, through the saturated zone to the Columbia River, and in the Columbia River to receptors downstream. The flow discharge in the Columbia River is assumed to be under low-flow conditions of 1000 cubic meters per second (36,000 cubic feet per second) (Whelan et al. 1987), which represents the most conservative case for maximizing surface water concentrations. As a conservative assumption, the removal of water from the Columbia River is assumed to be 100 meters (328 feet) downstream of the point of entry of the contaminant into the river. The assessment addressed recreational activities (e.g., boating, swimming, fishing) in the Columbia River and use of the water as a drinking-water supply and for bathing, irrigation, etc. The overall risk of fatal cancer from this accident was found to be less than 10 chances in a billion. (Whelan et al. 1994).

Table A-13. Consequences of cask drop accident at new wet storage facility adjacent to the 200-East Area.

A cask drop involving broken fuel elements falling out of the cask at a new wet storage facility would be tile same as discussed in Section A. 1. 1. 1. No prompt radiation illness or latent cancer fatalities would be~redictcd for workers in this scenario.

The accident scenario at the 105-ICE and 105-KW Basins and its results described under the No Action Alternative would also be applicable under the Decentralization Alternative prior to transport of fuel to a new storage facility.

A.1.2.2 New Dry Storage - Small Vault or Cask Facility. The maximum reasonably

foreseeable accident for the dry storage facility is assumed to be the same as that for a previously evaluated accident involving transport of FFTF fuel (DOE 1986b). This accident is used as a surrogate for a dry storage facility accident involving an impact by either an internal or external initiator that results in a fire. The release associated with this accident is estimated at 5.4E + 02 Ci, based on the hypothetical scenario of six FFTF fuel assemblies irradiated to 150 MWD/Kg being subjected to a severe impact followed by a fire. The fuel pins rupture on impact or on heating in the fire, which burns for an hour before being extinguished. The probability of such an accident resulting in b~ach of the transport cask is estimated to be 9 x 10(-7)or lower for 100 onsite shipments of FFw fuel. The estimated frequency for this accident in tile Decentralization Alternative has been adjusted to 6 x 10(-6) per year based on the quantity of fuel that would be handled in loading the dry storage facility. Volatiles, particulates, and noble gases are released to the atmosphere. The estimated radionuclide releases are listed in Table A-14, and the radiological consequences are presented in Table A-15.

Table A-14. Estimated radionuclide releases for cask impact accident and fire at new dry storage facility, based on FFTF fuel transport.

Table A-15. Consequences of cask impact accident with fire at new dry storage facility.

An internal or external initiator that causes a breach followed by fire in a dry storage facility would surely be noticed by nearby workers. In all likelihood, area radiation alarms would also sound. The assumed 12 workers would immediately evacuate the area and, once at a safe distance, would move to a position upwind of the building. Evacuation time to that location would be measured in minutes. The dose to close-in workers is speculated to be about 3 rem. The maximum probability of latent fatal cancer from such a dose would be 0.001. The postulated collective dose would amount to about 36 person-rem, from which no latent cancer fatalities would be expected.

A.1.2.3 New Fuel Stabilization Facility. The maximum reasonably foreseeable

radiological accident for fuel processing (either calcine or solvent extraction) is a uranium metal fire in a storage vessel (DOE l986b; Bergsman 1995). The frequency of this accident is estimated at 10A to l0~ per year. Releases for the accident from a new facility adjacent to the

200-East Area are listed in Table A-16. The total release assumes that fuel burns for a period of 20 hours; therefore, doses to onsite receptors were calculated on the basis that they were exposed for 2 hours (or 10 percent of the total release, assuming a constant release rate for the duration of the fire). The consequences of the accident are listed in Table A-17.

This accident involves a uranium fire in a storage vessel with releases of radioactive material to the atmosphere. There would be no added source of radiation exposure of the close-in worker in the processing facility.

A.1.3 1992/1993 Planning Basis Alternative

Accidents and consequences would be essentially the same as those for the Decentralization Alternative.

A.1.4 Regionalization Alternative

Accidents and consequences would be essentially the same as for the Decentralization Alternative. The accident frequencies for a cask impact and fire at handling and storage facilities were adjusted to account for the quantity of imported or exported fuel handled in each of the suboptions at a receiving and canning facility or in loading storage facilities. For Regionalization A (all fuel except defense fuel would be shipped offsite) the frequency was assumed to be the same as in Decentralization (6E-06 per year). The frequency in Regionalization B (Western fuel comes to Hanford) is slightly higher (7E-06) because of the additional fuel that would be handled. The Regionalization Alternative is assigned a lower frequency (5E-06) when all SNF is shipped offsite.

Table A-16. Estimated airborne radionuclide release from shear/leach/ calcine stabilization facility as a result of maximum reasonably forseeable accident (uranium metal fire in storage vessel).

Table A-17. Consequences of uranium metal fire at fuel stabilization facility.

A.1.5 Centralization Alternative

The Centralization Alternative consists of two options at Hanford - a minimum option in which all DOE spent fuel at Hanford is transported offsite to another location for interim storage, and a maximum alternative that would result in storage of all DOE spent fuel at Hanford. Accident scenarios for the minimum option would include those discussed under the No Action Alternative prior to shipment of the fuel offsite. In addition, N reactor and SPR fuel would be stabilized prior to shipment in a facility simflar to the shear/leach/calcine facility discussed under the Decentralization Alternative. The uranium metal fire accident discussed under that alternative is assumed to be the maximum reasonably foreseeable accident for a stabilization facility in this case as well. The estimated frequency for the cask impact and fire at storage or canning and shipping facilities has been adjusted to 5 x 10(-6) per year based on the quantity of fuel that would be handled in the centralization minimum alternative.

The maximum option contains suboptions for wet or dry fuel storage with processing similar to those for the Decentralization Alternative, and the consequences are expected to be essentially the same as those described previously. The estimated frequency for the cask impact and fire at a receiving and canning or dry storage facility has been adjusted to 8 x l0~ per year based on the quantity of imported fuel that would be handled in the Centralization Alternative, maximum option. The only additional installation that would be included in this option is the Expended Core Facility (ECF), which would be relocated from the INEL. The consequences of accidents at this facility are discussed in Volume 1, Appendix D of this document. It should be noted that the accident evaluation for the ECF at Hanford in Appendix D uses assumptions that are different from those used for the Hanford accidents in this attachment and therefore the risks associated with the ECF at Hanford cannot be compared directly with those for the other Hanford facilities presented here. The consequences of the ECF accidents using Hanford Site assumptions would be higher than those presented in Appendix D.

A.2 Nonradiological Accidents

For purposes of the analysis, a worst-case accident scenario was developed for each existing and planned facility. The details of the nonradiological accident scenario are presented in this section. The scenario involves a chemical spili within a building, followed by an environmental release from the normal exhaust system. It is assumed that the building remains intact but containment measures fail, allowing release to occur through the ventilation system. It is assumed that all, or a portion of, the entire inventory of toxic chemicals stored in each building is released. The environmental releases are modeled and the hypothetical concentrations at three receptor locations are compared to toxicological limits.

A.2.1 Chemical Lists

Chemical inventory and chemical emissions lists have been developed provided by alternative and facility (Bergsman 1995). These chemical lists are of three basic types. The first type is a "worst-case chemical inventory," prepared to comply with the Emergency Planning and Community Right-To-Know Act reporting requirement. For facilities that store SNF, this lists which ones are of particular interest. The second type, presented in the Facility Costs section, is a general statement listing proposed process chemicals. The third type of list is an estimate of proposed liquid effluents and airborne emissions, presented in the Facility Discharges section. Effluent and emissions data are not presented for every option.

A.2.2 Baseline Chemical Inventory Based on Existing Facilities

A baseline inventory of chemicals kept in SNF facilities was developed from chemical Inventories for these facilities that were compiled to comply with the Emergency Planning and Community Right-To-Know Act. The existing storage facilities are 105-ICE Basin, 105-KW Basin, PUREX (202A), T Plant (22 IT), 2736-ZB Building, 200W low-level burial grounds, Fast Fuel Test Facility (FFTF) (403 Building), 308 Building, 324 Building, 325 A&B Building, and 327 Building. The Emergency Planning and Community Right-To-Know Act lists used are from 1992.

Because most facilities have various missions, the need for an inventory of chemicals at these facilities may not be related to the storage of SNF. The assumption is made that the existing inventories represent the amounts and types of chemicals that may be needed in the future.

Table A-15 lists chemicals by facility, the regulated reportable quantity (RQ) in the event of an environmental release, the maximum quantity stored, its physical state (gas, solid, liquid), the reference where the chemical is listed, the hypothetical release fraction (1 for gases, 0.1 for liquids, and 0.01 for solids), the calculated total hypothetical chemical release, and the chemical's probable use.

In the table, a solid frame around a number indicates that a stored quantity exceeds the reportable quantity for that chemical; a double-lined frame indicates that a conservative hypothetical accidental release would exceed the reportable quantity. A total of seventeen chemicals fail in the latter category and have the highest probability to be released to the air. These seventeen chemicals are the ones that would demand the highest attention in an emergency plan.

Because a reportable quantity has itt been defined for every chemical, the inherent toxicity of each chemical was also considered in assessing its importance. The release fractions used in the accidental spill scenario are conservative, higher than those reported in the literature by as much as three orders of magnitude (Hickey et al. 1991).

A.2.3 Proposed Facilities

Table A-19 is primarily derived from the Facility Costs section of the engineering design data (Bergsman 1995). However, the 105-KE Basin is used as a surrogate for a baseline chemical inventory for the wet storage facility because the Facility Cost section lists only sodium hydroxide and suffuric acid.

Table A-19 lists chemicals by facility, the regulated reportable quantity (RQ) in the event of an environmental release, the maximum quantity stored, its physical state (gas, solid, liquid), the reference where the chemical is listed, the hypothetical release fraction (1 for gases, 0.1 for liquids, and 0.01 for solids), the calculated total hypothetical chemical release, and the chemical's probable use. In the table, a solid frame around a number indicates that a stored quantity exceeds the reportable quantity for that chemical; a double-lined frame indicates that a conservative hypothetical accidental release would exceed the reportable quantity. A total of six chemicals fall in the latter category and have the highest probability to be released to the air. These six chemicals are the ones that would demand the highest attention in an emergency plan.

A.2.4 Atmospheric Modeling

Effects to onsite workers, the nearest point of pubic access, and the public at the nearest offsite residence were estimated using the computer model EPlcode (DOE 1993b). EPicode uses a straight line Gaussian plume model and characteristics of an individual chemical to estimate downwind concentrations independent of direction. The 95 percent meteorological parameters were used to determine the wind speeds and stability class used for the simulation. In each case, stability class F was used. Wind speeds of 0.89 meters per second (2.0 miles per hour) were used for calculating effects to an onsite worker, the nearest point of public access, and at the nearest offsite residence. Other criteria used in the model simulations can be found in DOE (1993a).

Table A-18. Baseline Chemical Inventory for Existing Facilities in SNF Storage Locations (Page 1)

Table A-18. Page 2 Table A-18. Page 3 Table A-18. Page 4 Table A-18. Page 5 Table A-19. Baseline Chemical Inventory for Proposed Facilities.(Page 1) Table A-19. (Page 2) Table A-19. (Page 3) A.2.5 Toxicological Limits

Results from the EPlcode model were compared to available Emergency Response Planning Guideline (ERPG) values, Immediately Dangerous to Life and Health (IDLH) values, and Threshold Limit Values/Time-Weighted Averages. In the absence of these values, toxicological data for similar health endpoints, obtained from the Registry of Toxic Effects for Chemical Substances (RTEC), are used.

Emergency Response Planning Guidelines are estimates of airborne concentration thresholds above which one can reasonably anticipate observing adverse effects (DOE 1993b). Emergency Response Planning Guideline values are specific for a substance and are divided into three general severity levels: ERPG.l, ERPG-2, and ERPG-3. ERPG-1 values result in an unacceptable likelihood that one would experience mild transient adverse health effects or perception of a clearly defined objectionable odor (DOE 1993b). ERPG-2 values result in an unacceptable likelihood that one would experience or develop irreversible or other serious health effects or symptoms that could impair one's ability to take protective action (DOE 1993b). ERPG-3 values result in an unacceptable likelihood that one would experience life-threatening health effects (DOE 1993b).

For many chemicals, ERPG levels are not defined. In these instances, Threshold Limit Value/Time-Weight Average (TLV/TWA) values are substituted for ERPG-l values. Ten percent of Immediately Dangerous to Life or Health (IDLH) values are substituted for ERPG-2 values, and IDLH values are substituted for ERPG-3 values (DOE 1993b).

Data from RTEC were used for eight chemicals. Acute toxicity data were utilized to generate exposure limits to approximate the ERPG endpoints--irritation/odor, irreversible health effects, and death.

All references for Attachment A are included
in Chapter 7 of this Appendix

ATTACHMENT B

EVALUATION OF OPTION FOR FOREIGN PROCESSING OF SPENT
NUCLEAR FUEL CURRENTLY LOCATED AT THE HANFORD SITE

B.1 Description of Foreign Processing Alternative

This option was considered in response to a public comment requesting that foreign processing of N Reactor spent nuclear fuel (SNF) from the Hanford Site be addressed as a reasonable alternative to domestic stabilization and storage. Under this alternative, the SNF currently stored in basins at the 100-K Area of the Hanford Site would be packaged for shipment to an overseas facility where it would be processed. Only production reactor fuel stored at the 100-K Basins was considered in this analysis because it represents a large quantity of relatively homogenous material that would require stabilization in order to be suitable for 40-year storage. Small quantities of other types of fuel currently stored at Hanford either would not require stabilization or would have sufficiently different characteristics that they could not be stabilized efficiently by a single-process facility.

This analysis assumes that high-level waste (HLW) arising from the process would be returned to Hanford for interim storage, although it could potentially be stored overseas until a domestic repository was available in which to permanently dispose of it. Similarly, uranium and plutonium resulting from the processing were presumed to be returned to Hanford for interim storage; however, these materials could also be stored overseas until a decision is made on their disposition by the U.S. Department of Energy (DOE).

The following analysis was undertaken despite substantial uncertainties concerning the feasibility of long-distance transport of SNF in its current condition from the Hanford Site. Approximately half of the SNF is currently stored underwater at the 100-K West Basin in sealed, vented containers, and the remaining fuel is at 100-K East Basin in containers that are open to water. Efforts to characterize the physical and chemical state of the SNF are just getting underway, and those studies may reduce the uncertainties associated with long-distance transport of this SNF.

The SNF shipment would be required to meet national and international regulations specifying integrity of the cask seal in the event of internal pressure build-up, acceptable gas concentrations inside the cask, and allowable quantities of dispersible radionuclides. Because the defense production reactor SNF suffered damage during handling and discharge from the reactors, and because it was not designed for long-term durability in wet storage, a substantial fraction of the fuel elements have degraded during the time since reactor operations ceased (ranging from 7 to more than 20 years). The Hanford SNF in its present condition may not meet these requirements because of the quantity of dispersible radionuclides in damaged and corroding SNF, or because of heat generation and possible buildup of gases within the shipping container that might result from reactions between SNF and water in the wet overpack.

If the Hanford fuel were not able to meet the transportation requirements, the overseas processing alternative would necessitate additional expense and risk to stabilize the fuel or to divide the shipments into smaller quantities than assumed for the present analysis, perhaps to the extent that it might prove to be impractical altogether. The overland transport evaluation presented in Volume 1, Appendix I of this EIS assumed that Hanford SNF was in a stabilized form prior to shipment, as described in this appendix. Because of the uncertainties surrounding the feasibility of long-distance transport of Hanford SNF in its present condition, and to be consistent with the overland transport analysis in Appendix I, the SNF for overseas shipment is also presumed to be stabilized prior to shipment or is limited to elements that are sufficiently intact that the requirements of the transportation regulations could be met using a wet overpack shipping system. The shipment quantities assumed in the overseas transport analysis include the total mass of SNF estimated to be in the K Basins, although some of the SNF is known to exist as corrosion products and sludge, which would not be suitable for shipment without prior treatment to convert them into a less dispersible form.

B.2 Methods and Assumptions

The following sections describe the methods used to evaluate potential consequences of the overseas processing option. The analysis focuses on the activities associated with transportation of the SNF to the United Kingdom (U.K.) for processing and return of the waste and products to the U.S. The analysis also includes activities at Hanford to prepare the SNF for shipment, as well as those associated with transport and processing of the SNF within the U.K., to the extent that information was available. Information from an overseas processing facility located in the U.K. was used as the basis for this evaluation (BNFL 1994). However, the use of those facilities as a representative case would not preclude processing of SNF from Hanford at another suitable overseas installation.

B.2.1 Shipping Scenarios

Potential shipping scenarios are described in this option for transporting irradiated N Reactor fuel from the Hanford Site to the U.K., and the return of separated plutonium, uranium, and HLW to Hanford. All scenarios assume stabilization and packaging, as necessary, of the SNF currently stored in the 100-K Area Basins on the Hanford Site. From the 100 Area, the SNF would be loaded for onsite or offsite transport as required for each scenario. Offsite transport would take place via either barge, truck, or rail to a port designated as a "facility of particular hazard" in accordance with 33 CFR 126, where the shipment would be loaded onto a ship for overseas transport. The overseas segment of the shipment was assumed to utilize purpose-built ships typical of those employed by the representative processing facility in the U.K. for shipping SNF (BNFL 1994). Such a system would likely be necessary if Hanford SNF were to be shipped without prior stabilization because alternative carriers would presumably not have either the equipment or expertise required for long-distance transport of metallic SNF in a wet overpack. If the SNF were stabilized before shipment, a variety of commercial or military shipping options might be available (see DOE 1995 for a discussion of those options).

After processing of the SNF, the products and wastes were assumed to be returned to Hanford for interim storage via the same U.S. seaport at which the initial shipments exited the country. The three materials addressed in the analysis for the return shipments are plutonium, uranium, and HLW. It was assumed that the separated plutonium and uranium would be converted to oxide forms and shipped to the U.S. aboard a purpose-built ship similar to that used for transporting the irradiated fuel. Other transport options might also be available for these materials, including use of military or commercial ships or aircraft. High-level waste was assumed to be processed to a stable form (borosilicate glass encased in stainless steel canisters) before shipment. This section provides descriptions of the shipping scenarios, transportation and packaging systems, radiological characteristics of the shipments, transportation routes, and port facilities that were examined in this analysis.

B.2.1.1 Port Selection. Ports evaluated for the foreign processing option were chosen to minimize either

the overland or ocean segments of the shipments and to provide a reasonable range of alternative transportation modes between the Hanford Site and the port (i.e., barge, truck, or rail). For the purposes of this evaluation, two potential West Coast U.S. ports (Seattle/Tacoma, Washington, and Portland, Oregon) and one potential East Coast port (Norfolk, Virginia) were evaluated for the overland transportation analysis. Population densities along the routes to these ports are representative of those in the vicinity of many major U.S. seaports. In addition, the port of Newark, New Jersey, was included in the port accident analysis to estimate the consequences of an accident in a location with a very high surrounding population.

B.2.1.2 Overseas Transport. The routing for overseas transport from West Coast U.S. ports would include

transit via the Columbia River or Puget Sound to the Pacific Ocean, a southerly route through the Panama Canal or around Cape Horn in South America, and then north to the U.K. The route around the cape is considered because it maximizes the distance that a shipment might be required to travel, and therefore, provides an upper bound for risks associated with the ocean transport segment. However, a route via the Panama Canal would be preferable for West Coast shipments because it avoids potential risk associated with the added distance and adverse weather conditions that might be encountered during transport around the cape. Transport via an East Coast U.S. port would be directly across the Atlantic Ocean to the U.K. The total distance for ocean transport via the West Coast is approximately 7,000 nautical miles via the Panama Canal or 17,000 nautical miles via Cape Horn; that for the East Coast is approximately 3000 nautical miles.

B.2.1.3 Overland Transport Scenarios. Overland transport between the Hanford Site and overseas shipping

ports was evaluated for three different scenarios, as described in the following sections.

B.2.1.3.1 Barge to Portland, Transoceanic Shipment to the U.K. This scenario begins with cask

loading operations at the Hanford Site 100-K Area Basins. The shipping casks would be loaded with SNF and prepared for truck transport to the Port of Benton barge slip near the 300 Area of the Hanford Site. After arrival at the barge slip, the shipping casks would be transloaded onto the barge via crane and then secured to the deck of the barge. After a full load of casks was secured, the barge would depart for the Port of Portland, Oregon, traveling down the Columbia River through routinely navigated shipping channels. At the Port of Portland, the shipping casks would be lifted off the barge and placed aboard a ship for the overseas segment of the journey. The shipping casks would then be secured, and the ship would depart for the U.K. After processing of the SNF, the HLW shipments were assumed to return via Portland, where the material would be transloaded onto a rail car and transported to Hanford for interim storage. Shipments of uranium and plutonium oxide would be returned to Hanford by truck.

B.2.1.3.2 Truck/Rail to the Port of Seattle, Transoceanic Shipment to the U.K.

The first leg of this scenario is different from the barge-to-Portland scenario in that the shipping casks would be loaded at the K Basins and shipped directly to the Port of Seattle, Washington, for transloading onto the ocean-going vessel. The overland leg would consist of either truck or rail shipments. It was assumed that one shipping cask would be transported per truck shipment or two casks per rail shipment. After arrival at the Port of Seattle, the shipping casks would be transloaded onto the ocean-going vessel and when a shipload of casks had been loaded, the ship would sail through Puget Sound and the Strait of Juan de Fuca to the Pacific Ocean, travel south via either the Panama Canal or Cape Horn, and then north to the U.K. After processing, the uranium, plutonium, and vitrified HLW would be returned to the U.S. by ship via Seattle and finally to Hanford by truck or rail.

B.2.1.3.3 Truck/Rail to the Port of Norfolk, Virginia, Transoceanic Shipment to the U.K.

This scenario would be similar to the truck/rail to Seattle scenario except the intermediate port would be Norfolk, Virginia. Similar to the Port of Seattle scenario, the shipping casks would be loaded aboard the ocean-going vessel and shipped to the U.K. This shipping scenario maximizes the overland transport leg and minimizes the ocean travel distance. As with the other two shipping scenarios, the solidified HLW, plutonium oxide, and uranium oxide materials were assumed to be returned to Hanford via Norfolk.

B.2.2 Shipping System Descriptions

This section presents descriptions of the shipping cask and truck, rail, and barge shipping systems that are used in the three potential shipping scenarios. The information presented focuses on the parameters important to the impact calculations, namely the cargo capacities and radionuclide inventories.

The shipping cask assumed to be used for the SNF shipments from Hanford to the U.K. is a standard design routinely used for commercial SNF transport (BNFL 1994). The cask could transport approximately 5 tons of intact fuel (with a smaller capacity for damaged fuel). The loaded cask weight is about 46 tons, so it was assumed that one cask could be transported per highway shipment and two per rail shipment. The capacities of the barge and ship were assumed to be 24 casks each. A total of 17 transoceanic shipments would be required to accommodate the 408 caskloads that would be necessary to ship all Hanford SNF. The actual number of shipments required would depend on the number of casks available, or on procurement of a sufficient number of new casks to provide for efficient shipment of Hanford SNF on a reasonable schedule.

The radionuclide inventories for the SNF shipments were determined using the information on N Reactor fuel inventories presented in Bergsman (1994). The resulting radionuclide inventories for the three types of shipments (truck, rail, and barge/ship) are presented in Table B-1.

The return shipments of HLW and plutonium and uranium oxide were assumed to be shipped via the same routes used for overseas shipment of Hanford SNF. For the barge to Portland option, these materials were assumed to be returned to the U.S. by ship to the Port of Portland, where HLW shipping casks would be transloaded onto a barge and uranium and plutonium onto trucks for transport to Hanford. Similarly for the other options, the materials would be transported by ships to the ports of Norfolk or Seattle, transloaded onto truck or rail shipping systems, and transported to Hanford.

The number of shipments of solidified HLW was estimated using assumed shipping cask capacities for HLW. It is estimated that a total of 500 containers of vitrified HLW, each weighing about 500 kg, would result from processing the N Reactor SNF (BNFL 1994). The U.K. processing facility has designed a new 110-ton shipping cask for vitrified HLW that would be capable of carrying 21 HLW containers per shipment. Therefore, about 24 caskloads would be required to return the HLW to the U.S. This material was assumed to be transported to a U.S. port facility in one shipment and then transloaded onto a rail car for the overland shipment segment (the HLW cask is too large to be transported by regular truck service). The actual number of shipments required would depend on the number of HLW casks available or on procurement of a sufficient number of new casks to provide for efficient return shipment of HLW on a reasonable schedule.

The radionuclide inventories for the solidified HLW shipments are presented in Table B-1. These inventories were calculated by dividing the total quantity of each radionuclide shipped to the U.K. (exclusive of uranium and plutonium) by the number of HLW casks (24) to be returned to the U.S.

Table B-1. Facility and transport mode radionuclide inventory development[a]

Radionuclide	Curies/ MTU	Grams/ MTU	Total Curies in SNF	Curies/Shipment[b]				Curies/Shipping Cask[c]	
				Truck	Rail	Barge	HLW[d]	Plutonium Oxide[e]	Uranium Oxide[e]
Shipments				408	204	17	24/1	186	236
Duration				5 years	5 years	5 years	7 months	2.3 years	2.9 years
H3	4.59E+01		9.64E+04	2.36E+02	4.73E+02	5.67E+03	4.02E+03		
Fe-55	1.22E+01		2.56E+04	6.28E+01	1.26E+02	1.51E+03	1.07E+03		
Co-60	8.78E+00		1.84E+04	4.52E+01	9.04E+01	1.08E+03	7.68E+02		
Kr-85	8.07E+02		1.69E+06	4.15E+03	8.31E+03	9.97E+04	7.06E+04		
Sr-90	9.32E+03		1.96E+07	4.80E+04	9.59E+04	1.15E+06	8.16E+05		
Y-90	9.32E+03		1.96E+07	4.80E+04	9.59E+04	1.15E+06	8.16E+05		
Ru-106	8.52E+01		1.79E+05	4.39E+02	8.77E+02	1.05E+04	7.46E+03		
Rh-106	8.52E+01		1.79E+05	4.39E+02	8.77E+02	1.05E+04	7.46E+03		
Sb-125	2.02E+02		4.24E+05	1.04E+03	2.08E+03	2.50E+04	1.77E+04		
Te-125	4.94E+01		1.04E+05	2.54E+02	5.09E+02	6.10E+03	4.32E+03		
Cs-134	3.01E+02		6.32E+05	1.55E+03	3.10E+03	3.72E+04	2.63E+04		
Cs-137	1.20E+04		2.52E+07	6.18E+04	1.24E+05	1.48E+06	1.05E+06		
Ba-137m	1.14E+04		2.39E+07	5.87E+04	1.17E+05	1.41E+06	9.98E+05		
Ce-144	3.97E+01		8.34E+04	2.04E+02	4.09E+02	4.90E+03	3.47E+03		
Pr-144	3.97E+01		8.34E+04	2.04E+02	4.09E+02	4.90E+03	3.47E+03		
Pr-144m	4.77E-01		1.00E+03	2.46E+00	4.91E+00	5.89E+01	4.17E+01		
Pm-147	2.72E+03		5.71E+06	1.40E+04	2.80E+04	3.36E+05	2.38E+05		

Table B-1. (contd)

Radionuclide	Curies/ MTU	Grams/ MTU	Total Curies in SNF	Curies/Shipment[b]				Curies/Shipping Cask[c]	
				Truck	Rail	Barge	HLW[d]	Plutonium Oxide[e]	Uranium Oxide[e]
Shipments				408	204	17	24/1		

186	236						
Duration				5 years	5 years	5 years	7 months 2.3 years 2.9 years
Sm-151	1.10E+02		2.31E+05	5.66E+02	1.13E+03	1.36E+04	9.63E+03
Eu-154	2.17E+02		4.56E+05	1.12E+03	2.23E+03	2.68E+04	1.90E+04
Eu-155	5.14E+01		1.08E+05	2.65E+02	5.29E+02	6.35E+03	4.50E+03
U-234	4.34E-01	6.94E+01	9.11E+02	2.23E+00	4.47E+00	5.36E+01	3.73E+00
U-235	1.60E-02	7.39E+03	3.35E+01	8.22E-02	1.64E-01	1.97E+00	1.37E-01
U-236	7.63E-02	1.18E+03	1.60E+02	3.93E-01	7.86E-01	9.43E+00	6.57E-01
U-238	3.31E-01	9.84E+05	6.94E+02	1.70E+00	3.40E+00	4.08E+01	2.85E+00
Np-237	4.75E-02		9.98E+01	2.45E-01	4.89E-01	5.87E+00	4.16E+00
Pu-238	1.22E+02		2.56E+05	6.28E+02	1.26E+03	1.51E+04	1.33E+03
Pu-239	1.36E+02	2.20E+03	2.86E+05	7.02E+02	1.40E+03	1.68E+04	1.48E+03
Pu-240	9.94E+01	4.38E+02	2.09E+05	5.12E+02	1.02E+03	1.23E+04	1.08E+03
Pu-241	8.71E+03	8.46E+01	1.83E+07	4.49E+04	8.97E+04	1.08E+06	9.48E+04
Pu-242	6.45E-02	1.64E+01	1.35E+02	3.32E-01	6.63E-01	7.96E+00	7.01E-01
Am-241	1.84E+02		3.86E+05	9.47E+02	1.89E+03	2.27E+04	1.61E+04
Cm-244	2.62E+01		5.50E+04	1.35E+02	2.70E+02	3.24E+03	2.29E+03

a. Radionuclide inventory taken from Bergsman (1994) and represents 10-year cooled Mark 1A fuel, in which Pu-240 constitutes 16% of total plutonium.

b. Curies/shipment inventories assume 1 cask per truck shipment, 2 truck casks per rail, and 24 truck casks per barge shipment.

c. Curies/cask inventories are based on one cask per truck and/or rail shipment.

d. HLW - Solidified high level waste; inventory assumes 100% removal of plutonium and uranium. High-level waste to be shipped only by barge (24 casks per barge) or rail (1 cask per rail car).

e. Plutonium and uranium oxide inventories assume 100% removal, and the number of shipments has been adjusted to reflect conversion from metal to oxide. Plutonium and uranium oxide to be shipped by barge and truck only.

The number of shipments of uranium and plutonium oxide were estimated using standard U.S. shipping equipment for uranium and plutonium. The estimated quantities to be shipped include 2,360 tons of purified uranium oxide and 6.5 tons of plutonium oxide generated from processing the K Basin SNF. For this analysis, it was assumed that the plutonium oxide would be transported by truck in a Type B package with a capacity of 35 kg/shipment. This results in a total of 186 caskloads of plutonium oxide. The vehicle for transport of plutonium was assumed to be a Safe-Secure Trailer/Armored Tractor specifically designed for shipment of special nuclear materials within the U.S. The uranium oxide was assumed to be transported by truck in shipping systems with a capacity of 10,000 kg/shipment. This would require a total of 236 caskloads of uranium oxide. One caskload per truck shipment for overland segments was assumed. One sea shipment of uranium oxide and one of plutonium oxide were assumed to be required.

The radionuclide inventories for the plutonium oxide and uranium oxide shipments are presented in Table B-1. The inventories were determined by dividing the total quantities of uranium and plutonium to be shipped to the U.K. by the respective numbers of caskloads presented above.

B.2.3 Transportation Route Information

The overland transportation routes assumed for this analysis are described in the following section. The descriptive information includes the shipping distances and population density data. These data were developed using the HIGHWAY (Johnson et al. 1993a) and INTERLINE (Johnson et al. 1993b) computer codes for truck and rail shipments, respectively, and are used to calculate transportation impacts. These data are summarized below for each transport segment described in Section B.2.2. No population data are presented for the ocean segments because once at sea, the exposed population becomes essentially zero.

Hanford to Seattle, Washington: The truck and rail shipping distances from Hanford to Seattle were determined to be 277 km (172 miles) and 716 km (445 miles), respectively. The large difference in shipping distance arises from the fact that the rail route is not a direct link to Seattle, but travels from Hanford to Vancouver, Washington and then to Seattle. For the highway route, the shipment travels through 88.1% rural areas (weighted population density 4.5 persons/km2), 10% in suburban areas (359 persons/km2) and 1.9% in urban population zones (1870 persons/km2). The rail route travels through 74.1% rural areas (9.8 persons/km2), 19% in suburban zones (415.5 persons/km2), and 6.9% in urban areas (2226 persons/km2).

Hanford to Norfolk, Virginia: The truck and rail shipping distances from Hanford to Norfolk were determined to be 4585 km (2849 miles) and 4984 km (3097 miles), respectively. For the highway route, the shipment travels through 84.5% rural areas (7.3 persons/km2), 13.4% in suburban areas (365 persons/km2) and 2.1% in urban population zones (2299 persons/km2). The rail route travels through 83% rural areas (7.8 persons/km2), 14.5% in suburban zones (360.4 persons/km2), and 2.4% in urban areas (2149 persons/km2).

Hanford to Portland, Oregon: The only option evaluated for using the Port of Portland was to barge the SNF to Portland, where it would be transloaded onto the ship. The distance and population density information for this shipment was approximated using INTERLINE (Johnson et al. 1993b), which evaluates potential rail routes, because the rail lines closely follow the Columbia River in which the barge would be operating. Consequently, the route data for a barge shipment would be similar to that for a rail shipment. The rail data are thought to be more conservative than actual barge data because the rail lines pass closer to the city centers along the river than would a barge.

B.2.4 Description of Methods Used to Estimate Consequences

This section describes the methods used to estimate consequences of normal and accidental exposure of individuals or populations to radioactive materials. The RADTRAN 4 (Neuhauser and Kanipe 1992) and RISKIND (Yuan et al. 1993) computer codes were used to calculate the transportation impacts, and the GENII software package (Napier et al. 1988) was used to estimate the consequences of port accidents. The MICROSHIELD external dosimetry software (Grove Engineering 1988) was used to determine approximate external dose rates for shipping containers as input to the transportation consequences. Nonradiological impacts from both incident-free transport and accidents were also evaluated.

The output from computer codes, as total effective dose equivalent (TEDE or dose) to the affected receptors, was then used to express the consequences in terms of potential latent cancer fatalities (LCF). Recommendations of the International Commission on Radiological Protection (ICRP 1991) for low dose, low dose rate radiological exposures were used to convert dose as TEDE to LCF. The conversion factor applied to adult workers was 4 x 10-4 LCF/rem TEDE, and that for the general population was 5 x 10-4 LCF/rem TEDE. The general population was assumed to have a higher rate of cancer induction for a given radiation dose than healthy adult workers because of the presence of more sensitive individuals (e.g., children) in the general population.

The estimated LCF for potential accidents was multiplied by the expected accident frequency per year, per shipment, or for the entire duration of the foreign processing operation, to provide a point estimate of risk consistent with those reported in the remainder of this EIS. Incident-free transportation or normal facility operations were assumed to occur (i.e., they have a frequency of 1.0); therefore, the cumulative risks associated with normal operations would be identical to the predicted number of latent cancer fatalities for the duration of the operation.

Nonradiological incident-free and accident impacts were also evaluated. Nonradiological incident-free impacts consist of fatalities from pollutants emitted from the vehicles. Nonradiological accident impacts are the fatalities resulting from potential vehicular accidents involving the shipments. Neither of these two categories of impacts are related to the radiological characteristics of the cargo. Estimates of these nonradiological impacts were derived by multiplying the unit risk factors (fatalities per mile of travel) by the total shipping distances for all of the shipments in each shipping option. Nonradiological unit risk factors for incident-free transport were taken from Rao et al. (1982), and for vehicular accidents were taken from Saricks and Kvitek (1994).

B.2.4.1 RADTRAN 4 Description. The RADTRAN 4 computer code (Neuhauser and Kanipe 1992) was used to

perform the analyses of the radiological impacts of routine transport, the integrated population risks of accidents during transport of irradiated N-Reactor SNF to the U.K., and the return of vitrified HLW, plutonium oxide, and uranium oxide from the U.K. to Hanford. RADTRAN was developed by Sandia National Laboratories (SNL) to calculate the risks associated with the transportation of radioactive materials. The original code was written by SNL in 1977 in association with the preparation of NUREG-0170, Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes (NRC 1977). The code has since been refined and expanded and is currently maintained by SNL under contract with DOE. RADTRAN 4 is an update of the RADTRAN 3 (Madsen et al. 1986) and RADTRAN 2 (Taylor and Daniel 1982, Madsen et al. 1983) computer codes.

The RADTRAN 4 computer code is organized into the following seven models (Neuhauser and Kanipe 1992):

- material model
- transportation model
- population distribution model
- health effects model
- accident severity and package release model
- meteorological dispersion model
- economic model.

The code uses the first three models to calculate the potential population dose from normal, incident-free transportation and the first six models to calculate the risk to the population from user-defined accident scenarios. The economic model is not used in this study.

B.2.4.1.1 Material Model. The material model defines the source as either a point source or as a line

source. For exposure distances less than twice the package dimension, the source is conservatively assumed to be a line source. For all other cases, the source is modeled as a point source that emits radiation equally in all directions.

The material model also contains a library of 59 isotopes each of which has 11 defining parameters that are used in the calculation of dose. The user can add isotopes not in the RADTRAN library by creating a data table in the input file consisting of eleven parameters.

B.2.4.1.2 Transportation Model. The transportation model allows the user to input descrip-

tions of the transportation route. A transportation route may be divided into links or segments of the journey with information for each link on population density, mode of travel (e.g., trailer truck or ship), accident rate, vehicle speed, road type, vehicle density, and link length. Alternatively, the transportation route also can be described by aggregate route data for rural, urban, and suburban areas. For this analysis, the aggregate route method was used for each potential origin-destination combination. The origin-destination combinations addressed in this analysis were discussed in Section B.2.1.

B.2.4.1.3 Health Effects Model. The health effects model in RADTRAN 4 is outdated and is replaced by

hand calculations. The health effects are determined by multiplying the population dose (person-rem) supplied by RADTRAN 4 by a conversion factor.

B.2.4.1.4 Accident Severity and Package Release Model. Accident analysis in RADTRAN 4 is performed

using the accident severity and package release model. The user can define up to 20 severity categories for three population densities (urban, suburban, and rural), each increasing in magnitude. Eight severity categories for SNF containers that are related to fire, puncture, crush, and immersion environments are defined in NUREG-0170 (NRC 1977). Various other studies also have been performed for small packages (Clarke et al. 1976) and large packages (Dennis et al. 1978) that also can be used to generate severity categories. The accident scenarios are further defined by allowing the user to input release fractions and aerosol and respirable fractions for each severity category. These fractions are also a function of the physical-chemical properties of the materials being transported.

B.2.4.1.5 Meteorological Dispersion Model. RADTRAN 4 allows the user to choose two different

methods for modeling the atmospheric transport of radionuclides after a potential accident. The user can input either Pasquill atmospheric-stability category data or averaged time-integrated concentrations. In this analysis, the dispersion of radionuclides after a potential accident is modeled by the use of time-integrated concentration values in downwind areas compiled from national averages by SNL.

B.2.4.1.6 Incident-Free Transport. The models described above are used by RADTRAN 4 to determine

dose from incident-free transportation or risk from potential accidents. The public and worker doses calculated by RADTRAN 4 for incident-free transportation are dependent on the type of material being transported and the transportation index (TI) of the package or packages. The TI is defined in 49 CFR 173.403(bb) as the highest package dose rate in millirem per hour at a distance of 1 m from the external surface of the package. Dose consequences are also dependent on the size of the package, which as indicated in the material model description, will determine whether the package is modeled as a point source or line source for close-proximity exposures.

B.2.4.1.7 Analysis of Potential Accidents. The accident analysis performed in RADTRAN 4 calculates

population doses for each accident severity category using six exposure pathway models. The exposure pathways are inhalation, resuspension, groundshine, cloudshine, ingestion, and direct exposure. This RADTRAN 4 analysis assumes that any contaminated area is either mitigated or public access controlled so the dose via the ingestion pathway equals zero. The consequences calculated for each severity category are multiplied by the appropriate frequencies for accidents in each category and summed to give a total point estimate of risk for a radiological accident. The parameters used to calculate the frequencies and consequences of transportation accidents are presented in Section B.2.4.2.

B.2.4.2 RADTRAN 4 Input Parameters. RADTRAN 4 input parameters for calculating routine population

doses include route information (shipping distances, population densities, and fractions of travel in rural, suburban, and urban areas), numbers of shipments, dose rate, and parameters that define the population exposure characteristics. The route information and numbers of shipments were presented in Section B.1.2 and will not be repeated here. The remaining exposure parameters are described below.

RADTRAN 4 uses the dose rate at 1 m (referred to as the TI) in calculating dose to the public and worker. All of the SNF and HLW shipments in this analysis were assumed to be at the regulatory maximum dose rate, which is 10 mrem per hour at a distance of 2 m from the cask surface. This would be equivalent to a TI of 13 (or a dose rate of 13 mrem/hr at 1 m from the surface). Although it is likely that many of these shipments will have significantly smaller TI values, the use of the regulatory maximum value is bounding because it cannot be exceeded.

Because shipments of plutonium oxide and uranium oxide would have much smaller dose rates than SNF or HLW, preliminary shielding calculations were performed to derive more realistic values. The computer code MICROSHIELD (Grove Engineering 1988) was used to perform these calculations. Both types of shipments were modeled as cylindrical sources with cylindrical shields. The parameters used in these calculations are shown below:

- Plutonium oxide: The plutonium source was assumed to be 12.7 cm in diameter and 127 cm in length. Shielding was assumed to be provided by a 1-cm thick steel shield and an 8-cm thickness of solid hydrogenous material. The source inventory was the same as that shown in Table B-1.

- Uranium oxide: The uranium source was modeled as a single large container although the shipment will most likely be composed of several smaller containers. The source dimensions were assumed to be 114 cm in diameter and 370 cm in length. The source was assumed to be surrounded by a 1-cm thick steel cylinder and a 3-cm thick shield of solid hydrogenous material. The source inventory was shown in Table B-1.

The dose rate at 1 m from the surface of the plutonium oxide shipment was calculated to be 0.019 mrem/hr. Because this was increased by a factor of five to provide a bounding estimate, the TI value for these shipments was set to 0.1 mrem/hr. The dose rate for the uranium oxide shipments was calculated to be 0.0049 mrem/hr. This was also increased by a factor of five to 0.025 mrem/hr for conservatism.

Table B-2 is a list of input parameters that are used by RADTRAN 4 in the calculation of population dose for incident-free transportation. Many of the parameters are default values in the RADTRAN 4 code. Those that are not default values are identified and their sources are provided in footnotes to the table.

The potential receptors include workers and the general public. Worker doses include those received by the truck, rail, or barge crew and package handlers aboard the barge. Although RADTRAN models package handlers as persons who handle packages during intermediate stops, the routine doses to this group were assumed to apply to personnel who inspect the shipping containers aboard the barge. The equations used to calculate these doses assume that a five-person team spends approximately 0.5 hr per handling operation (or per inspection tour of the shipping casks). Although not exact, this is believed to be a reasonable approximation.

Table B-2. Input parameters for analysis of incident-free impacts[a]

Parameter	Rail	Barge	Truck
Dose rate 1 m from vehicle/package (mrem/h)[b]	13.1	13.1	13.1
Length of package (m)	3.0	3.0	3.0
Exclusive use	No	Yes	Yes
Velocity in rural population zone (km/h)[c]	64.4	16.09	88.6
Velocity in suburban population zone (km/h)[b]	40.3	8.06	40.3
Velocity in urban population zone (km/h)[c]	24.2	3.20	24.2
Number of crewmen	5	2	2
Distance from source to crew (m)	152	45.70	10.0
Stop time per km (h/km)[c]	0.033	0.01	0.011
Persons exposed while stopped[c]	100	50	50
Average exposure distance while stopped (m)[c]	20.0	50.0	20.0
Number of people per vehicle on link[c]	3	0	2
Traffic count passing a specific point-rural zone,one-way[c]	1.0	0	470
Traffic count passing a specific point-suburban zone,one-way[c]	5.0	0	780
Traffic count passing a specific point-urban zone,one-way[c]	5.0	0	2,800

a. Values shown are shipment-specific unless otherwise noted.
b. These values were used for SNF and HLW shipments. See text for the derivation of TI values for plutonium oxide (0.1 mrem/hr) and uranium oxide shipments (0.025 mrem/hr).
c. Default values from RADTRAN (Neuhauser and Kanipe 1992 and Madsen et al. 1983).

Public doses include doses to persons on the highway or railway (this category is not applicable to barge shipments as indicated in the RADTRAN documentation), doses to persons who reside near the highway, railway, or river, and doses at stops (for barge transport, this was assumed to include stops at navigation locks in dams).

For all three shipping modes, the doses to passengers were assumed to be 0.0 because there would be no passengers traveling with the shipments. In addition, there were assumed to be no intermediate storage needs for the shipments, and the doses to in-transit storage personnel were set equal to 0.0.

Information needed to characterize the potential routes between Hanford and the U.K. include the shipping distances, population densities in rural, suburban, and urban areas along the routes, and fractions of total shipping distance that travel through rural, suburban, and urban areas. These data were presented in Section B.2.3.

B.2.4.3 RISKIND Description. RISKIND (Yuan et al. 1993) was used to calculate doses to the maximum

individual and the public for both rail and truck transportation accidents. RISKIND was originally developed to model incident-free and accident conditions during transportation of SNF. The code was specifically designed to model accidental releases based on data contained in the NRC modal study (Fischer et al. 1987). RISKIND is designed to calculate the dose to individuals or groups of individuals for each of the severity categories identified in the modal study and provide probability-weighted dose risk, acute fatality, latent fatality, and genetic effect values. The probability-weighted dose risk values are calculated by multiplying and summing the dose for each severity category times the fraction of accidents within each severity category. Health effects are calculated by multiplying probability-weighted dose risk values by appropriate conversion factors. For this analysis, point estimates of risk for latent cancer fatalities were estimated as described in Section B.2.4.

The code is comprised of subroutines or models used to calculate radiological exposures to individuals at specific receptor locations. The information used to calculate these exposures can be performed using the default values contained in RISKIND or using receptor-specific data, supplied by the user. The exposure calculations are performed based on the receptor location, exposure conditions (i.e., inhalation and ingestion intake rates), and meteorological conditions.

RISKIND can be used to model all environmental exposure pathways based on the duration of the exposure. That is, for acute or short-term exposures, RISKIND can calculate exposures from initial plume passage or loss of shipping-cask shielding. For chronic or long-term exposures, RISKIND calculates exposures from ground deposition and ingestion from the food-chain pathways.

A radiological source inventory is contained internal to RISKIND that is based on fuel type, cooling times, and burnup rates. An analyst can input other radiological source inventories to calculate scenario-specific exposures. The radiological source inventory for this analysis is shown in Table B-1.

To calculate doses to the receptor, cask accident responses for both truck and rail, and release fractions have been incorporated into RISKIND. This information is based on the NRC modal study (Fischer et al. 1987). As discussed earlier, all shipments will be performed using Type B shipping containers; therefore, it is appropriate to use RISKIND to calculate the dose to the maximally exposed individual for all waste forms.

B.3 Radiological Dose to Workers

The following sections describe expected radiological consequences to workers during transportation and processing of N-Reactor SNF from Hanford.

B.3.1 Worker Dose from Pre-Shipment Activities at Hanford

Packaging of the K-Basin SNF for temporary wet storage was estimated to result in worker doses of approximately 140 person-rem (5.5 x 10-2 LCF) over a period of about 2 years. The activities covered by this estimate include repacking fuel assemblies in both K-East and K-West Basins and disposing of empty canisters (DOE 1992). The consequences of preparing the fuel for overseas shipment were assumed to be similar for the purposes of this evaluation. If stabilization of the fuel prior to shipment were necessary, an additional 180 person-rem might be accumulated by onsite workers over a 4-year period, resulting in 7.0 x 10-2 LCF (see Section 5.12.5 of this appendix). Consequences of air emissions from the storage or stabilization facilities to nearby workers would be much lower than those from direct exposure of workers in these facilities (see Section 5.7 of this appendix).

The consequences of accidents at the wet storage facility or the stabilization facility are discussed in Section 5.15 of this appendix. Air emissions from a fuel handling accident at the 100-K Basins or a uranium fire at the stabilization facility would result in a point estimate of risk to the nearby workers of <1.4 x 10-7 LCF or <8.3 x 10-12 LCF per year of operation, respectively. The estimated frequency for both accidents is between 1 x 10-6 and 1 x 10-4 per year. Operations at the K Basins to package SNF for shipment would last approximately 2 years, and the stabilization facility would require 4 years to process all of the K Basin SNF. The consequence to workers that might be directly involved in such accidents is highly speculative, and is addressed in Attachment A-Facility Accidents.

B.3.2 Worker Doses from Transportation to U.S. Ports

This section discusses the results of the worker impact calculations for truck, rail, and barge shipments to and from the U.K. These doses were calculated using the RADTRAN 4 computer code (Neuhauser and Kanipe 1992). The RADTRAN 4 program uses a combination of meteorological, demographic, health physics, transportation, packaging, and material factors to analyze risks associated with both normal transport (incident-free) and various user-selected accident scenarios. The RADTRAN 4 computer code description for both routine and accident impacts was presented in Section B.2.4.

The results of the incident-free transportation impact calculations are presented in Table B-3. The radiological impacts are presented in terms of the population dose (person-rem) received by exposed workers and the projected health effects calculated to occur in the exposed population. As shown, no excess fatalities were calculated to result from any of the five transportation options considered in this study.

As shown in Table B-3, the transportation option to U.S. ports that results in the lowest worker population doses is that involving barge shipments to the Port of Portland. This option is closely followed by the option of shipping by rail to the Port of Seattle. The option involving truck transport to the Port of Seattle is the third lowest option. The option of shipping by rail to the Port of Norfolk is next, followed by the option of shipping by truck to the Port of Norfolk. This result is intuitively obvious because the shipping distances are much longer from Hanford to Norfolk than to the other ports.

Table B-3. Results of incident-free transportation impact calculations for workers.

Option and material	Radiation doses, person-rem	Latent cancer fatalities
Barge to Portland		
SNF	3.0E+00	1.2E-03
HLW	1.8E-01	7.0E-05
Pu	7.7E-02	3.1E-05
U	5.3E-02	2.1E-05
TOTAL	3.3E+00	1.3E-03
Truck to Seattle		
SNF	6.0E+00	2.4E-03
HLW (Rail)	3.8E-01	1.5E-04
Pu (Truck)	4.5E-02	1.8E-05
U (Truck)	3.4E-02	1.3E-05
TOTAL	6.5E+00	2.6E-03
Rail to Seattle		
SNF	3.2E+00	1.3E-03
HLW (Rail)	3.8E-01	1.5E-04
Pu (Truck)	4.5E-02	1.8E-05
U (Truck)	3.4E-02	1.3E-05
TOTAL	3.7E+00	1.5E-03
Truck to Norfolk		
SNF	1.0E+02	4.2E-02
HLW (Rail)	1.5E+00	5.9E-04
Pu (Truck)	7.7E-01	3.1E-04
U (Truck)	5.8E-01	2.3E-04
TOTAL	1.1E+02	4.3E-02
Rail to Norfolk		
SNF	1.3E+01	5.0E-03
HLW (Rail)	1.5E+00	5.9E-04
Pu (Truck)	7.7E-01	3.1E-04
U (Truck)	5.8E-01	2.3E-04
TOTAL	1.5E+01	6.1E-03

In general, the shipments of N Reactor SNF to the U.K. would produce the highest doses of all the materials. This is attributed primarily to the higher number of N Reactor SNF shipments than the other materials. Also, it can be seen that rail shipments generally result in lower worker doses than truck shipments. This is because the exposure distances between the source and crew are much longer for rail shipments than for truck shipments. Similarly, the crew doses for rail and barge shipments are approximately comparable.

Maximum individual doses to workers from incident-free transport were calculated using the RISKIND computer code, consistent with the approach described in Volume 1, Appendix I. The maximally exposed workers for truck shipments were found to be the truck drivers (two-person crew), who were assumed to drive shipments for up to 2,000 hour per year. The maximally exposed worker for rail shipments was a transportation worker in a rail yard who spent a time- and distance-weighted average of 0.16 hours inspecting, classifying, and repairing railcars and was assumed to be present for all of the radioactive shipments.

The maximum incident-free exposure calculations for workers were performed for each shipping option. The results are 1.46 person-rem for the barge to Portland option, 2.0 person-rem for the option of shipping to Seattle by truck, 1.03 person-rem for the option of shipping to Seattle by rail, 35.3 person-rem for the option of shipping to Norfolk by truck, and 17.9 person-rem for the option of shipping to Norfolk by rail.

B.3.3 Worker Dose from Port Activities

The following sections describe expected radiological consequences to workers from in-port activities for transport of SNF to the U.K. The consequences for return of HLW, uranium, and plutonium are expected to be similar to, or lower than, those for initial shipment of SNF to the U.K. because of the smaller number of HLW shipments required for return to the U.S. Radiological consequences of normal transport of uranium and plutonium would be small compared with those for SNF and HLW.

B.3.3.1 Consequences of Normal Port Activities. Consequences to workers during handling and loading

activities in ports are based on commercial experience during the last three quarters of 1994. Over this period, workers handled two shipments consisting of 16 loaded casks, and 1 shipment consisting of 5 empty casks. The collective dose to the 30 workers involved was 0.024 person-rem, with the maximum individual receiving 0.016 rem. Assuming that handling of the empty casks did not contribute measurably to that total, the expected collective dose from handling a single loaded cask is estimated to be on the order of 0.001 rem to the maximally exposed worker and 0.0015 person-rem total to all workers. The consequences for loading and unloading of 408 casks during shipment from the U.S. to the U.K. would therefore be approximately 1.2 person-rem to all workers over the expected 5-year campaign. Accounting for an additional two handling activities per cask at the Hanford Site and at the U.K. process facility would roughly double that estimate, resulting in a collective dose of 2.4 person-rem and a potential for 9.8 x 10-4 LCF for all shipments. The maximum dose to an individual worker, assuming that worker were involved in handling all 408 casks at one point in the shipping sequence, would be on the order of 0.4 rem over 5 years.

B.3.3.2 Consequences of Accidents During Port Activities. The consequences of accidents during port

transit were estimated based on the highest activity N Reactor SNF (Bergsman 1994). The assumed radionuclide content of a single shipping cask is based on a loading of 5 MTU (see inventory for truck shipments in Table B-1). Representative ports on the West and East Coasts of the U.S. (Seattle-Tacoma, Washington; Portland, Oregon; Norfolk, Virginia; and Newark, New Jersey) were used for this analysis, based on relative population densities and suitability for handling of SNF shipments. Newark was included in this part of the analysis because of its relatively large surrounding population (adjacent to New York City), whereas the ports of Seattle-Tacoma, Portland, and Norfolk are located in somewhat smaller population centers. In a previous analysis, the collective consequences of in-port accidents were shown to be proportional to the surrounding population (DOE 1995).

The consequences (as radiation dose to individuals and populations and corresponding LCF were evaluated for a range of accident severities leading to airborne release of radioactive material, corresponding to the accident categories and radionuclide release fractions used for the overland transportation analysis (Volume 1, Appendix I, Table I-28). The overall accident frequency associated with each accident category was calculated using the conditional probability for that severity category, multiplied by the overall frequency with which a shipping accident would occur (as estimated by DOE 1994, Table E-8). The consequences (as LCF) for each severity category were multiplied by the corresponding frequency with which an accident in that category would occur to obtain a point estimate of risk for each accident category. The total risk per shipment was then calculated as the sum of risks over all accident severity categories. The frequencies for airborne release accidents evaluated using 95% atmospheric dispersion (stable) conditions (those that would not be exceeded more than 5% of the time) were assumed to be 10% of those evaluated using 50% (neutral) dispersion conditions, which are assumed to be the typical or expected conditions. The risk to U.S. ports for shipping all Hanford SNF overseas is the total risk per shipment times 17 shipments. The risk to U.K. ports is assumed to be comparable to that at U.S. ports.

The port accident analyses assume that the contents of a single cask were involved in any given accident. The probability that multiple casks could be breached in the event of an accident is smaller than that for a single cask, and the consequences would be proportional to the number of casks involved. Because of the construction of the special purpose ships, with eight segregated holds each containing at most three casks, an accident that would involve more than three casks is not considered to be reasonably foreseeable.

The consequences to an individual at a distance of 100 m, assumed to be a port worker, was estimated for applicable exposure pathways including inhalation, external dose from submersion in the plume, and external exposure from radionuclides deposited on the ground for a period of 2 hours. The point estimates of risk for an accident at the Port of Portland are estimated to be 6.1 x 10-11 to 1.0 x 10-09 LCF for 1 to 17 shipments, respectively. The corresponding point estimates of risk for Seattle/Tacoma (based on wind data from Seattle-Tacoma airport and the population within 50 miles of the Port of Tacoma) ranged from 4.7 x 10-11 to 8.0 x 10-10 LCF. The point estimates of risk to workers at East Coast ports were similar - ranging from 6.1 x 10-11 to 1.0 x 10-09 LCF at Norfolk and 5.3 x 10-11 to 9.0 x 10-10 LCF at Newark.

The maximum reasonably foreseeable accident was a category 6 accident, which has a frequency of 1.3 x 10-7 per port transit, and which was evaluated for stable atmospheric conditions resulting in a cumulative frequency of 2.2 x 10-7 for all 17 SNF shipments. The dose to the port worker was estimated to be 1.7 rem at Seattle/Tacoma, 1.9 rem at Newark, and 2.1 rem at Portland and Norfolk. The corresponding probability of LCF ranged from 6.8 x 10-4 and point estimates of risk, from 1.5 x 10-9 to 1.8 x 10-9 LCF.

B.3.4 Worker Dose from Ocean Transport to the United Kingdom

The following sections describe radiological consequences to workers from normal transport operations and accidents during overseas shipments of SNF from the Hanford Site to the U.K.

B.3.4.1 Consequences of Normal Ocean Transit. The primary impact of routine (incident-free) marine

transport of SNF is potential radiological exposure to crew members of the ships used to carry the casks. Members of the general public and marine life would not receive any measurable dose from the SNF during incident-free marine transport of the casks. While at sea, the crew dose would be limited to those individuals who might enter the ship's hold during transit and receive external radiation in the vicinity of the packaged SNF. At all other times, the crew would be shielded from the casks by the decking and other structures of the vessel. The number of entries and inspections would be a function of the transit time from the port of loading to the port of off-loading.

External radiation from an intact shipping package must be less than specified limits that control the exposure of the handling personnel and general public. These limits are established in 49 CFR Part 173. The limit of interest is a 10 mrem/hr dose rate at any point 2 m from the outer surfaces of the transport cask. This limit applies to exclusive-use shipments, i.e., a shipment in which no other cargo is loaded on the platform used for the transportation casks, not that the ship is an exclusive-use vessel, although this would not be a limitation for the commercial special purpose ships assumed for this analysis.

It is anticipated that the external dose rates at the outside of the transport casks would be much less than the regulatory limits. It was estimated that the N Reactor SNF considered in this analysis would fall within the design envelope of the internationally licensed casks routinely used by the U.K. facility for SNF transport (BNFL 1994). However, estimates of dose during normal transportation have been made assuming dose rates at the regulatory limits, using analyses performed for transport of foreign research reactor SNF as a basis (DOE 1995). These analyses may be used to develop an upper bound of the doses anticipated to be received by ships crews during transport of the N Reactor SNF. Actual doses would be expected to be lower than these estimates.

B.3.4.1.1 Bounding Dose Calculations. Calculations performed to estimate bounding radiation doses during routine cask inspections aboard ship (DOE 1995) provided information from which an inspection dose factor (IDF) could be determined of 6 x 10-5 rem y minute-1 y cask-1 y day-1 y person-1, based on an average distance of 5.5 m. Because the ship crews are highly trained and the ships are designed for SNF transport, it was assumed that inspection of each of the eight holds on the ship (each containing three casks) would take no longer than 15 minutes, or an average of 5 minutes per cask for the total 24 casks. The total inspection time per day would be 2 hours. If an inspection crew were assumed to consist of two members of the ship's crew, the bounding dose per daily inspection would be

6 x 10-5 (IDF) x 5 minutes x 24 casks = 0.007 rem y person-1 y day-1 (1)

Assuming a travel time from an eastern U.S. port of 10 days, the estimated maximum dose received by each member of a two-person inspection crew would be 0.07 rem. This value would not exceed the 0.1 rem dose limit for a member of the general public. The transit time for a shipment originating on the West Coast of the U.S. could be up to five times longer, resulting in a dose per shipment of 0.35 rem. This value would exceed the 0.1 rem dose limit for a member of the general public. However, because the ship's crews are trained and issued dosimeters, it is presumed that they would be considered radiation workers. Although it is not clear at this time if radiation exposure of the ship's crew would fall under the jurisdiction of the U.K. or U.S. radiation protection standards, these standards are identical for both countries (5 rem per year, with an administrative control level of 2 rem per year). Therefore, the maximum possible dose received by individual workers during ocean transit would be well within the limits of the U.S. and U.K. radiation protection standards for workers.

Complete transport of the SNF to the U.K. for processing would require 17 shipments of 24 casks. The collective dose to crew members responsible for conducting inspections on the transport ships during fuel transport from the U.S. East Coast would be

(0.007 rem y person-1 y day-1) x 2 persons x (10 days y trip-1) x 17 trips = 2.4 person-rem (2)

Based on this bounding estimate of the collective dose to the ship's crew for transportation of the SNF, an upper limit of approximately 0.001 LCF would be expected among the ship's crew from exposure to external radiation from the SNF transport casks. If all shipments originated at a western U.S. port, the collective dose could be up to 12 person-rem with a corresponding consequence of 0.005 LCF.

The above analysis does not consider the return of the processed SNF products and waste from the U.K. to the U.S. It was projected that the number of shipments containing these products would be fewer than the number of SNF shipments. However, as a bounding estimate the same number of return shipments and similar external dose rates, at the regulatory limit, might be assumed. Under those circumstances, an upper limit of 0.01 LCF would be expected among the ships' crews from exposure to the external radiation during all shipments.

B.3.4.1.2 Commercial Fuel Transport Experience.

Information on radiation doses to ships' crews during transport of commercial fuel, gathered from actual crew dosimeters, supports the statements above that actual doses to the crew would be lower than the calculated bounding doses. The average individual dose during one voyage was 0.001 rem, with a maximum individual dose of 0.022 mrem. The collective dose to the ship's crew for one voyage was about 0.038 person-rem. On that basis, the crew's collective dose for 17 SNF shipments would be 0.65 person-rem. A comparison of bounding dose estimates and commercial transport experience is shown in Table B-4. Based on these results, less than 0.0003 LCF would be expected among ships' crews from radiation exposure during SNF transport, and approximately 0.0005 LCF would be expected from radiation exposure during transport of SNF and the subsequent return of processing products and waste.

Table B-4. Comparison of bounding and typical ship crew's doses.

	Bounding Dose Calculations	Commercial Fuel Transport Experience
Individual dose, rem	0.07 - 0.35	0.001 typical 0.022 maximum
Collective dose, person-rem		
- 17 SNF shipments	2.4 - 12	0.65
- < 17 round trips	< 24	< 1.3

B.3.4.2 Consequences of Accidents During Ocean Transit.

The consequences of accidents during ocean transit would likely be similar to those of port workers who are near the scene of an accident (see Section B.3.3.2). Individuals in the immediate vicinity of the impact would probably not survive an accident severe enough to cause release of radioactive materials from a SNF shipping cask. Effects on the ocean environment would not be expected to be discernable because of the degree of dispersion in the event of an airborne release.

B.3.5 Worker Dose from Return of Processing Products to the United States

Return of HLW to the U.S. is assumed to result in cumulative worker doses that are bounded by those incurred in the initial SNF shipments to the U.K. However, the distribution of dose among individual workers may differ because of the different configuration and radionuclide content of the HLW canisters. As noted in Section B.2.4.2, the dose rates associated with plutonium and uranium shipments are substantially below the regulatory maximum that was assumed for the SNF and HLW shipments.

B.4 Consequences to Members of the Public

The following sections describe expected consequences to the public from various activities involved in transporting N Reactor SNF to the U.K.

B.4.1 Public Impacts from Pre-Shipment Activities at Hanford

Activities at Hanford prior to preparation of N Reactor SNF for shipment would result in generally small consequences to the public, as discussed in Section 5.7 of this appendix. The removal and packaging of SNF at the basins was estimated to result in offsite consequences comparable to those observed during initial segregation of the fuel, or approximately 2 x 10-5 to 3 x 10-4 (1 x 10-11 to 1.5 x 10-10 probability of LCF) mrem to the maximally exposed offsite individual (DOE 1992).

The risk from accidents involving handling of N-Reactor SNF at the 100-K Basins was also presented in Section 5.15 of this appendix. The consequences to the maximally exposed offsite individual were estimated as 2.5 x 10-4 LCF, with an associated point estimate of risk equal to <2.5 x 10-8 fatal cancers per year (assuming an accident frequency <1 x 10-4 per year). The consequences to the population within 80 km (50 miles) were estimated as 0.4 LCF for 50% (neutral) atmospheric dispersion conditions and 6.9 LCF for 95% (stable) atmospheric dispersion (conditions that would not be exceeded more than 50% or 5% of the time, respectively). The corresponding point estimates of risk amounted to <4.0 x 10-5 and <6.9 x 10-4 LCF per year, respectively.

B.4.2 Public Impacts from Transportation Activities

This section presents the analysis of the public incident-free radiological exposures, radiological accident risks, and nonradiological impacts from transporting radioactive materials to and from the U.K. Members of the public exposed to radiation include persons on the highway, railroad, or waterway with the shipment, persons residing near these transport links, and persons at intermediate stops along the route (such as refueling stops and stops at rail classification yards). The RADTRAN 4 computer code was used to perform these calculations. A description of RADTRAN 4 was presented in Section B.2.4. The following sections present the results of the incident-free exposure calculations, description of the accident-analysis input parameters, the results of the accident risk impact calculations, and the evaluation of nonradiological impacts.

B.4.2.1 Results of Incident-Free Transportation Impact Calculations. The results of the public dose

calculations, developed using the RADTRAN 4 computer code and the input parameters described in Section B.2.4, are presented in Table B-5.

Table B-5. Results of public incident-free exposure calculations.

Option and material	Radiation doses, person-rem	Latent Cancer Fatalities
Barge to Portland		

SNF	3.4E-01	1.7E-04
HLW	6.7E-03	3.4E-06
Pu	3.7E-02	1.9E-05
U	2.9E-02	1.4E-05
TOTAL	4.1E-01	2.1E-04
Truck to Seattle		
SNF	1.5E+01	7.6E-03
HLW (rail)	1.9E-01	9.6E-05
Pu (truck)	2.5E-02	1.2E-05
U (truck)	1.9E-02	9.3E-06
TOTAL	1.5E+01	7.7E-03
Rail to Seattle		
SNF	1.6E+00	8.1E-04
HLW (rail)	1.9E-01	9.6E-05
Pu (truck)	2.5E-02	1.2E-05
U (truck)	1.9E-02	9.3E-06
TOTAL	1.9E+00	9.3E-04
Truck to Norfolk		
SNF	2.5E+02	1.3E-01
HLW (rail)	7.0E-01	3.5E-04
Pu (truck)	4.1E-01	2.1E-04
U (truck)	3.1E-01	1.6E-04
TOTAL	2.5E+02	1.3E-01
Rail to Norfolk		
SNF	5.9E+00	3.0E-03
HLW (rail)	7.0E-01	3.5E-04
Pu (truck)	4.1E-01	2.1E-04
U (truck)	3.1E-01	1.6E-04
TOTAL	7.3E+00	3.7E-03

From a domestic transportation perspective, the lowest-impact option is one that includes rail shipments of SNF from Hanford to the Port of Seattle. This option is followed closely by the option of moving SNF from Hanford to the Port of Portland by barge. The third lowest domestic transportation option is that involving SNF shipments to Seattle by truck. The highest impact options are those involving shipments from Hanford to the Port of Norfolk. Obviously, the lowest impact domestic transportation option would be that involving the shortest shipping distances (i.e., Hanford to Seattle or Portland). Some of the impacts of the long domestic transportation links would be offset by subsequent reductions in the lengths of the ocean shipment segments. Consequently, the rankings of the options presented in Table B-5 do not necessarily represent the rankings that would result if the ocean segments of the shipments were included. However, public routine doses are not significant for ocean voyages because the separation distance between the ship and the nearest exposed population is greater, resulting in extremely low radiation dose rates.

The results in Table B-5 demonstrate that barge shipments of SNF (and HLW) would produce lower public routine doses than truck or rail shipments. This is attributed primarily to the lower traffic volumes on waterways relative to railroads and highways, generally greater separation distances between barges and the public relative to the separation distances between highways/ railroads and the public, as well as the increased per-shipment capacities of barges relative to truck and rail shipments (resulting in fewer shipments).

Table B-5 also demonstrates that rail shipments would produce lower public routine doses than equivalent truck shipments. This can be seen by comparing the SNF shipment impacts for truck shipments to Seattle (15 person-rem) and rail shipments to Seattle (1.6 person-rem). Even though the rail shipping route from Hanford to Seattle is much longer than the truck route (277 km and 716 km), the total public routine doses are smaller. As with barge shipments, this is attributed to lower traffic volumes, larger separation distances, and increased shipment capacity for rail shipments.

Maximum individual doses to members of the public from incident-free transport were calculated using the RISKIND computer code, which is consistent with the approach described in Volume 1, Appendix I. For rail shipments, three potential exposure scenarios were evaluated by RISKIND, as described in Volume 1, Appendix I. The maximally exposed members of the public from incident-free truck transport were also determined using three potential exposure scenarios (see Volume 1, Appendix I).

The maximum incident-free exposure calculations for members of the public were performed for each shipping option. The results are 0.28 person-rem for the barge to Portland option, 0.20 person-rem for the option of shipping to Seattle by truck, 0.28 person-rem for the option of shipping to Seattle by rail, 0.20 person-rem for the option of shipping to Norfolk by truck, and 0.28 person-rem for the option of shipping to Norfolk by rail.

B.4.2.2 Assessment of Public Impacts from Transportation Accidents. Radiological accident impacts

are presented in this section as integrated population risks (i.e., accident frequencies multiplied by consequences integrated over the entire shipping campaign), as well as the consequences of the maximum reasonably foreseeable accident. Population risk calculations were performed using the RADTRAN 4 computer code (Neuhauser and Kanipe 1992). The consequences of the maximum reasonably foreseeable accident were calculated using the RISKIND computer code (Yuan et al. 1993). Separate sections are provided for the integrated population risk (i.e., RADTRAN 4) calculations and the maximum reasonably foreseeable accident consequence (i.e., RISKIND) calculations.

B.4.2.2.1 Integrated Population Risk Assessment. For this analysis, risk is defined as the product

of the frequency of occurrence of an accident involving a shipment and the consequences of an accident. Consequences are expressed in terms of the radiological dose and LCF from a release of radioactive material from the shipping cask or the exposure of persons to radiation that could result from damaged package shielding. The frequency of an accident that involves radioactive materials is expressed in terms of the expected number of accidents per unit distance integrated over the total distance traveled. The response of the shipping cask to the accident environment and the probability of release or loss of shielding, is related to the severity of the accident.

The frequencies of occurrence of transportation accidents that would release significant quantities of radioactive material are relatively small because the shipping casks are designed to withstand specified transportation accident conditions (i.e., the shipping casks for all the materials shipped in this analysis were assumed to meet the Type B packaging requirements specified in 49 CFR 174 and 10 CFR 71). Accidents on the road and railways are difficult to totally eliminate. However, because the shipping casks are capable of withstanding certain accident environments, including mechanical and thermal stress, only a relatively small fraction of accidents involve conditions that are severe enough to result in a release of radioactive materials.

Should an accident involving a shipment occur, a release of radioactive material could occur only if the cask were to fail. A failure would most likely be a small gap in a seal or small split in the containment vessel. For the radioactive material to reach the environment, it would have to pass through the split in the cask or through the failed seal. Materials released to the environment would be dispersed and diluted by weather action and a fraction would be deposited on the ground (i.e., drop out of the contaminated plume) in the surrounding region. Emergency response crews arriving on the scene would evacuate and secure the area to exclude bystanders from the accident scene. The released material would then be cleaned up using standard decontamination techniques, such as excavation and removal of contaminated soil. Monitoring of the area would be performed to locate contaminated areas and to guide cleanup crews in their choice of protective clothing and equipment (e.g., fresh-air equipment and filtered masks). Access to the area would be restricted by federal and/or state radiation control agencies until it had been decontaminated to safe levels.

The RADTRAN 4 computer code was used to calculate the radiological risk of transportation accidents involving radioactive material shipments. The RADTRAN 4 methodology was summarized previously. For further details, refer to the discussions presented by RADTRAN III (Madsen et al. 1986) and RADTRAN 4: Volume 2 -- Technical Manual (Neuhauser and Kanipe 1992).

There are five major categories of input data needed to calculate potential accident transportation risk impacts using the RADTRAN 4 computer code. These are: 1) accident frequency, 2) release quantities, 3) atmospheric dispersion parameters, 4) population distribution parameters, and 5) human uptake and dosimetry models. Accident frequency and release quantities are discussed below, the remaining parameters have been discussed in previous sections.

Accident Frequency. The frequency of a severe accident is calculated by multiplying an overall accident rate (accidents per truck-km or per rail-km) by the conditional probability that an accident would involve mechanical and/or thermal conditions that are severe enough to result in container failure and subsequent release of radioactive material. Overall accident rates per kilometer of truck or rail travel were taken from Saricks and Kvitek (1994). State-specific accident rates were used in this study. For the Portland and Norfolk options, a composite weighted-average accident rate was developed using the state-specific accident rates in Saricks and Kvitek (1994), and travel fractions through each state that were derived from the HIGHWAY and INTERLINE results.

For this analysis, six shipment-specific severity categories were defined, with category 1 as the least severe and the higher categories (2-6) representing increasingly severe conditions. The conditional probabilities of encountering accident conditions in each severity category were taken from a U.S. Nuclear Regulatory Commission (NRC) document (Fischer et al. 1987). Those conditional probabilities were developed based on reviews of accident records and statistics compiled by various state and federal agencies. The conditional probability for a given severity category is defined as the fraction of accidents that would fall into that severity category if an accident were to occur. The conditional probabilities for truck and rail shipments were determined using a binning process described in Volume 1, Appendix I of this EIS. The derivation of the accident rates and conditional probabilities used in this analysis are discussed below. [The conditional probabilities for barge accidents were taken directly from Pippen et al. (1995)].

As discussed above, severity category levels were defined to model the response of the various shipments to accidents. Severity category 1 was defined as encompassing all accidents that are within the type B package envelope that would not be severe enough to result in failure of the shipping cask (i.e., accidents with zero release). The higher categories (2-6) were defined to include more severe accidents, and thus may lead to a release of radioactive material. The derivation of the severity category schemes and conditional probabilities of accidents in each severity category are discussed below for each shipping cask or container type. Table B-6 presents the conditional probabilities of the various severity categories that were used in this analysis.

Release Fractions. Release fractions (array RFRAC in RADTRAN 4) are used to determine the quantity of radioactive material released to the environment as a result of an accident. The quantity of material released is a function of the severity of the accident (i.e., thermal and mechanical conditions produced in the accident), the response of the shipping container to these conditions, and the physical and chemical properties of the material being shipped. The basis for the release fractions used in this analysis are discussed below and summarized in Table B-7.

Release fractions for N Reactor fuel shipments were taken from Volume 1, Appendix I of this EIS. The table of release fractions for metallic fuels was used (Table I-28). All of the released material was assumed to be in respirable form for this assessment. Release fractions for damaged N Reactor SNF were modeled the same as for undamaged fuel. This is because it was assumed that some form of stabilization would occur prior to shipment of damaged SNF. Stabilization was assumed to provide a level of containment for damaged SNF, such as placement in an overpack container, to replace the containment boundary that was provided by the failed N Reactor SNF cladding. Stabilization was also assumed to include some form of treatment to minimize the likelihood of a pyrophoric reaction involving the metallic uranium and to prevent the accumulation of an explosive concentration of hydrogen gas that may be generated by the fuel elements.

Table B-6. Accident severity categories and conditional probabilities.

Mode	Conditional probability by severity category					
	1	2	3	4	5	6
Truck[a]	9.943E-01	4.03E-05	3.82E-03	1.55E-05	1.80E-03	9.84E-06
Rail[a]	9.940E-01	2.02E-03	2.72E-03	6.14E-04	8.55E-04	1.25E-04
Barge[b]	9.53E-01	2.02E-03	4.02E-02	6.41E-04	4.01E-03	1.34E-04
Ship[c]	6.03E-01	3.95E-01	2.0E-03	4.0E-04	4.0E-04	4.0E-04

a. Source: Fischer et al. (1987) and Volume 1, Appendix I, Figure I-2.
b. Source: Pippen et al. (1995).
c. Source: DOE (1994).

Table B-7. Release fractions used for assessment of accident impacts.

Material	Release fraction by severity category					
	1	2	3	4	5	6
SNF[a]						
Gases	0.0	9.9E-03	3.3E-02	3.9E-01	3.3E-01	6.3E-01
Cesium	0.0	3.0E-08	1.0E-07	1.0E-06	1.0E-06	1.0E-05
Ruthenium	0.0	4.1E-09	1.4E-08	2.4E-07	1.4E-07	2.4E-06
Particles	0.0	3.0E-10	1.0E-09	1.0E-08	1.0E-08	1.0E-07
HLW[a]	HLW release fractions are the same as those for SNF					
Pu oxide						
Particles	0.0	1.0E-06	1.0E-05	1.0E-04	1.0E-03	1.0E-02
U oxide						
Particles	0.0	1.0E-06	1.0E-05	1.0E-04	1.0E-03	1.0E-02

a. These release fractions were applied to truck and rail shipments of SNF and HLW. Release fractions for barge shipments were multiplied by 1/24, 1/12, 1/6, 1/3, and 1 for severity categories 2 through 6, respectively, to reflect the number of shipping casks that are damaged in each category.

A different, but related, set of release fractions were used for barge shipments of N Reactor SNF. The relationship deals with the potential involvement of multiple shipping casks in a barge carrying 24 of them. It is overly conservative to assume that all 24 shipping casks would fail in minor barge accidents. In the lower severity categories, the accident conditions are not severe enough to damage all 24 shipping casks. In fact, in the lowest severity category that results in a release, only the shipping casks in the vicinity of the collision would be affected. Consequently, the release fraction for severity category 2 was multiplied by 1/24 to reflect the assumption that only one of the total of 24 shipping casks aboard the barge would be damaged. Category 3 release fractions were multiplied by 1/12 to reflect the assumption that two shipping casks out of 24 would be damaged in the accident. The release fractions for severity categories 4, 5, and 6 were multiplied by 1/6, 1/3, and 1 to reflect the assumption that 4, 8, and all 24 casks would be damaged, respectively.

Release fractions for HLW shipments were assumed to be the same as those for SNF shipments. The difference is that the strength and durability of the vitrified HLW form was taken into account by assuming that not all of the materials released are in respirable or dispersable form. RADTRAN 4 default values for "immobilized" radionuclides were used to model the dispersable and respirable fractions of the released material. This means that the fraction of released material that is in dispersable form is 1.0E-06, and the respirable fraction is 5.0E-02 (Neuhauser and Kanipe 1992). The HLW release fractions for barge shipments were adjusted similarly to those for SNF to account for the fraction of casks that were assumed to be damaged in the six severity categories.

For plutonium and uranium oxide shipments, no data were readily available. Therefore, the release fractions presented in Table B-7 are representative approximations. It was assumed that 10% of the material released from the plutonium and uranium shipment accidents is in dispersable form and 5% of that is in respirable form, based on recommendations made by Neuhauser and Kanipe (1992) for shipment of small powder materials.

B.4.2.2.2 Consequences of Maximum Reasonably Foreseeable Accidents. The dose to the maximum individual and the collective population dose from the maximum reasonably foreseeable accident was calculated for each type of shipment, i.e., SNF, solidified HLW, and plutonium and uranium oxide. The quantity and radiological constituents of each waste form are discussed in Chapter 2.0 of this appendix.

The computer code RISKIND (Yuan et al. 1993) was used to calculate the dose to the maximum individual and the population.

RISKIND Input Parameters. This analysis evaluates the consequences of accidents involving truck or rail shipments. A separate assessment was not performed for barge shipments to Portland because of the similarity between the rail and barge routing data (see Section B.2.3). The radiological inventories developed in Table B-1 have been used to calculate the dose to the maximum individual and the public. For all analyses, inhalation doses were calculated for each of the NRC modal study severity categories, assuming the maximum individual was located 100 m from the point of release and neutral weather conditions (i.e., Atmospheric Stability Class = D and 4 m/s wind speed). To determine the maximum individual dose for each of the material types, the calculated dose for each of the NRC modal study categories (20) were binned into the accident severity categories shown in Table B-6. The results of the RISKIND calculations for each severity category are presented in Table B-8.

An accident frequency (accidents per year) and probable accident location by population zone (i.e., rural, suburban, and urban) were developed for each campaign, based on the type of material, transportation mode, transportation routing information, and state-specific transportation accident data. For this analysis a campaign is defined as the total number of shipments required to transport all of the material from the point of origin to the destination.

For each of the transportation modes, existing transportation model computer codes, i.e., HIGHWAY (Johnson 1993a; population data revised in 1994) and INTERLINE (Johnson 1993b; population data revised in 1994) were used to develop the route-specific information required for the accident analyses.

The information required to calculate the accident frequencies included the total number of shipments per campaign, the campaign duration, the total shipping distance, population zone-specific accident rates by state, and the conditional probabilities shown in Table B-6. The population zone-specific accident frequencies are calculated using the state-specific accident data (accidents per kilometer) for each of the population zones contained in Saricks and Kvitek (1994) and the distance traveled in each of the population zones. The resulting adjusted accident rates are shown in Table B-9. The values in this table were used to select the maximum reasonably foreseeable accident scenario.

Table B-8. RISKIND calculated doses summarized by severity categorya.

Severity Categoryb	Truck			Rail	
	Spent Nuclear Fuel (rem)	Pu Oxide (rem)	U Oxide (rem)c	Spent Nuclear Fuel (rem)	Solidified HLWd (rem)
1e	2.36E-05	2.36E-05	2.36E-05	2.36E-05	2.36E-05
2	8.59E-03	3.91E-04	2.36E-05	1.30E-01	1.26E-01
3	5.01E-02	1.25E-03	2.36E-05	8.53E-01	8.39E-01
4	9.39E-02	1.23E-02	2.36E-05	2.96E-01	1.26E-01
5	1.18E-01	1.23E-02	2.36E-05	9.80E-01	8.39E-01
6	2.60E-01	1.23E-01	2.36E-05	1.27E+00	8.39E-01

a. Maximum individual doses are in BOLD. (These doses were estimated in the event an accident occurs; i.e.,

they were not multiplied by the corresponding accident frequencies).
b. Severity categories are defined in Table B-6.
c. Only external doses were calculated.
d. The quantity of HLW released has been adjusted because of the immobilized form of the material. The adjustment, 1.0E-06, was taken from RADTRAN 4 (Neuhauser and Kanipe 1992).
e. Although, no material would be released, an external dose is calculated as a result of changes in the cask shielding caused by an accident impact.

The calculated maximum individual doses were cross referenced with the accident frequencies in Table B-9, and the maximum individual doses for reasonably foreseeable accidents (i.e., the accident frequency is greater than 1 x 10-7/year) have been reported.

The population dose from the maximum reasonably foreseeable accident is also provided. These analyses are based on the same assumptions used to calculate the dose to the maximally exposed individual. The location of the accident (or population zone) is the same as the accident location used to calculate the maximum individual doses.

The population densities for each of the impacted population zones were developed using HIGHWAY (Johnson 1993a) and INTERLINE (Johnson 1993b).

Table B-9. Summary of route-specific accident rates.

Total distance (km)	Distance per zone (km)			Travel fraction			Population zone accident rate (1.0E-07/km)		
	Rural	Suburban	Urban	Rural	Suburban	Urban	Rural	Suburban	Urban
Norfolk to Hanford - Truck									
4311.43	3640.28	619.48	51.67	0.84	0.14	0.01	2.508	3.369	4.129
Portland to Hanford -Truck									
416.82	353.25	50.21	13.36	0.85	0.12	0.03	2.279	2.802	3.675
Seattle to Hanford - Truck									
276.80	243.80	27.70	5.30	0.88	0.10	0.02	2.500	2.055	1.610
Norfolk to Hanford - Rail									
4984.78	4140.40	723.60	120.78	0.83	0.15	0.02	0.524	0.678	0.753
Portland to Hanford -Rail									
430.50	366.32	4921	14.97	0.86	0.11	0.03	0.361	0.298	0.271
Seattle to Hanford - Rail									
715.8	530.5	136.4	48.9	0.74	0.19	0.07	0.349	0.349	0.349

B.4.2.3 Results of Transportation Accident Impact Calculations. The results of the integrated population risk assessment are presented in Table B-10. The lowest impact option is that in which SNF is shipped from Hanford to the Port of Seattle by rail. The Port of Seattle by truck option is the next highest followed in order by the rail option to Norfolk, truck to Norfolk, and then barge to Portland. The impacts for all of the options are dominated by the SNF shipments to the U.K. and plutonium oxide return shipments to Hanford, primarily because the quantities and forms of these materials are more vulnerable to accidental releases and represent higher radiotoxicities than vitrified HLW and uranium oxide. Shipments of vitrified HLW were determined to present the lowest impacts of all the materials because of the reasons given plus the immobilized form of the material relative to the other materials.

Shipments by barge are shown in Table B-10 to result in relatively higher accident impacts than shipments by rail or truck. This is because the inventories of radioactive materials transported by barge, and the resulting potential accident releases, are at least an order of magnitude greater than for truck and rail shipments. Because the accident rates for the three modes are comparable, this results in a higher per shipment (or per-km) accident risk for barge than the other modes. This higher per-shipment risk more than offsets the risk reduction attributable to fewer barge

Table B-10. Results of transportation accident risk assessmenta.

Option and material	Accident impacts, person-rem	Latent cancer fatalities
Barge to Portland		

SNF	1.8E-02	9.0E-06
HLW	1.5E-08	7.5E-12
Pu	9.3E-03	4.7E-06
U	2.7E-06	1.4E-09
TOTAL	2.7E-02	1.4E-05
Truck to Seattle		
SNF	9.3E-05	4.7E-08
HLW (Rail)	1.6E-10	8.0E-14
Pu (Truck)	3.6E-03	1.8E-06
U (Truck)	1.1E-06	5.5E-10
TOTAL	3.7E-03	1.9E-06
Rail to Seattle		
SNF	6.3E-05	3.2E-08
HLW (Rail)	1.6E-10	8.0E-14
Pu (Truck)	3.6E-03	1.8E-06
U (Truck)	1.1E-06	5.5E-10
TOTAL	3.7E-03	1.8E-06
Truck to Norfolk		
SNF	2.1E-03	1.1E-06
HLW (Rail)	9.3E-10	4.7E-13
Pu (Truck)	8.3E-02	4.1E-05
U (Truck)	2.4E-05	1.2E-08
TOTAL	8.5E-02	4.2E-05
Rail to Norfolk		
SNF	7.4E-04	3.7E-07
HLW (Rail)	9.3E-10	4.7E-13
Pu (Truck)	8.3E-02	4.1E-05
U (Truck)	2.4E-05	1.2E-08
TOTAL	8.3E-02	4.2E-05

a. Reported values are point estimates of risk; i.e., the accident frequency multiplied by the consequences that would be expected if an accident occurred.

shipments so, overall, barge accident risks appear to be higher than truck or rail transport risks. However, in comparing the magnitudes of the accident risks in Table B-8 to the public routine exposures in Table B-5, it can be seen that the accident risks are lower than the routine public exposures. Consequently, it may be concluded that transportation accident risk impacts are insignificant contributors to the total impacts of the transportation options.

The results of the maximum reasonably foreseeable accident consequence assessment are provided in Tables B-11 through B-14. The results in these tables were generated using the RISKIND computer code. The following paragraphs discuss the results of the maximally exposed individual consequence assessment for each material. This is followed by a discussion of the results of the collective dose calculations.

N Reactor SNF. As discussed in Section 2.0, SNF will be loaded into shipping casks at the K Basins and transported by barge, truck, or rail to ocean ports for shipment to the U.K. Two shipping modes and three transportation routes were evaluated. The radiological source inventory used in the analysis was shown in Table B-1. The release fractions used here were taken from Volume 1, Appendix I of this EIS (see Table B-7). The results of the evaluation are shown in Table B-11.

As can be seen in Table B-11, for reasonably foreseeable events (i.e., the accident frequency is greater than 1.0E-07/year), the dose received by the maximally exposed individual from a rail accident ranges from 9.80E-01 to 1.27E+00 rem depending on the location of the individual and transportation route. The potential LCF range from 4.90E-04 to 6.35E-04. The accident frequency also varies based on the transportation route and accident location from 1.27E-07 to 1.91E-06/year. Table B-11 also presents the dose received by the maximally exposed individual from a truck accident. The dose to the maximally exposed individual ranges from 1.18E-01 to 2.60E-01 rem, depending on the location of the individual and transportation route. The accident frequency also varies based on the transportation route and accident location from 1.23E-07 to 1.02E-05/year. The potential LCF range from 5.90E-05 to 1.30E-04.

Collective doses to the public were also calculated for each of the transport modes and transportation route (see Table B-11). For this analysis, it was assumed that the accident occurred in the same location as that determined in the maximum individual dose calculations. The population dose from a rail accident ranges from

3.18E+00 to 3.27E+02 person-rem depending on the accident location, population density, and transportation route.

The doses to population from a truck accident range from 1.37E-01 to 9.44E+02 person-rem. The potential LCF range from 1.59E-03 to 0.170 for rail and 6.85E-05 to 4.72E-1 for truck.

Table B-11. Calculated maximum individual and population radiological doses and latent cancer fatalities based on accident location and frequency of SNF shipments.

Transportation Route	Mode	No. of ship-mentsa	Accident frequency (per year)b	Accident location: population zonec	Maximum individual TEDEd (rem)	Maximum individual LCFe	Population TEDEd (person-rem)	Population LCFe
Hanford, Washington to Portland, Oregon	Truck	408	1.23E-07	Urban	2.60E-01	1.30E-04	1.01E+02	5.05E-02
Hanford, Washington to Seattle, Washington			1.02E-05	Rural	1.18E-01	5.90E-05	1.37E-01	6.85E-05
Hanford, Washington to Norfolk, Virginia			1.43-06	Urban	2.60E-01	1.30E-04	9.44E+02	4.72E-01
Hanford, Washington to Portland, Oregon	Rail	204	3.46E-07	Rural	9.80E-01	4.90E-04	3.18E+00	1.59E-03
Hanford, Washington to Seattle, Washington			1.27E-07	Urban	1.27E+00	6.35E-04	3.39E+02	0.170
Hanford, Washington to Norfolk, Virginia			1.91E-06	Urban	1.27E+00	6.35E-04	3.27E+02	0.164

a. Assumes one truck cask per truck shipment and two truck casks per rail shipment.
b. Accident frequency based on the number of shipments, campaign duration, one-way shipping distance, and conditional probability.
c. Accident location is based on population zone where the maximum individual dose occurs.
d. TEDE - 50-year total effective dose equivalent.
e. LCF - Latent cancer fatalities. Calculated on dose (rem) to maximum individual or population, i.e., 5.0E-04 LCF/rem

Table B-12. Calculated maximum individual and population radiological doses and latent cancer fatalities based on accident location and frequency for plutonium oxide shipments.

Transportation Route	Mode	No. of Ship.	Accident Frequency (per year)b	Accident Location: Population Zonec	Maximum Individual TEDEd (rem)	Maximum Individual LCFse	Population TEDEd (rem)	Population LCFse
Portland, Oregon to Hanford, Washington	Truck	186	1.22E-07	Urban	1.23E-01	6.15E-05	1.88E+01	9.40E-03
Seattle, Washington to Hanford, Washington			1.01E-05	Rural	1.23E-02	6.15E-06	3.46E-03	1.73E-06
Norfolk, Virginia to Hanford, Washington			1.42E-06	Urban	1.23E-01	6.15E-05	1.77E+01	8.85E-03

a. Assumes one cask per truck shipment.
b. Accident frequency based on the number of shipments, campaign duration, one-way shipping distance, and conditional probability.
c. Accident location is based on population zone where maximum individual dose occurs.
d. TEDE - 50 year Total Effective Dose Equivalent.
e. LCFs - Latent cancer fatalities. Calculated based on dose (rem) to maximum individual or population, i.e., 5.0E-04 LCFs/rem

Plutonium Oxide. The separated plutonium oxide was assumed to be returned to its point of origin (i.e., Hanford). This material was assumed to be transported to a U.S. port (Seattle, Portland, or Norfolk) by ocean-going ship and offloaded to a Safe-Secure Trailer/Armored Tractor for subsequent highway shipment to Hanford (one container per shipment).

The results of this analysis are provided in Table B-12. The dose, to the maximally exposed individual from the maximum reasonable foreseeable accident, ranges from 1.23E-02 to 1.23E-01 rem, depending on the location of the individual and transportation route. The potential LCF ranges from 5.90E-06 to 5.90E-05. The accident frequency ranges from 1.22E-07 to 1.01E-05/year depending on the transportation route and accident location.

The potential population doses from the maximum reasonably foreseeable accident have also been calculated and are shown in Table B-12. Assuming that the accident occurs in the same location or population zone as that determined for the maximally exposed individual, the population dose ranges from 3.46E-03 to 1.88E+01 person-rem. The potential LCF range from 1.73E-06 to 9.40E-03.

Uranium Oxide. As with plutonium oxide, uranium oxide resulting from SNF processing was assumed to be returned to Hanford. This material was assumed to be transported by ship to a port facility where it would be offloaded onto a truck for subsequent highway transport to Hanford. As with the plutonium oxide, only truck accidents were evaluated. The calculated dose received by the maximum individual from a truck accident is 2.36E-05 rem (see Table B-13). The potential LCF are 1.18E-08. The accident frequency ranges from 1.23E-07 to 1.01E-05 per year depending on the transportation route and accident location.

The potential collective dose ranges from 3.65E-06 to 1.98E-03 person-rem depending on the location and transportation route. The potential LCF range from 1.83E-09 to 9.90E-07 and also depend on the accident location and transportation route.

Solidified High-Level Waste. Following separation of all plutonium and uranium from the N Reactor fuel, the resulting HLW was assumed to be vitrified and poured into canisters. These canisters were assumed to be shipped in rail shipping casks by ship to a U.S. port facility and offloaded to rail cars at the port; therefore, only rail accidents were evaluated for shipments of HLW. The radiological source inventory used in the analysis was shown in Table B-1 and the release fractions were shown in Table B-7. Because the waste material that has been solidified in glass logs was considered to be "immobilized" material, the fraction of released material that is also dispersable and the fraction that is also respirable were adjusted, as discussed in Section 4.2.2.1.

Table B-13. Calculated maximum individual and population radiological doses and latent cancer fatalities based on accident location and frequency for uranium oxide shipments.

Transportation route	Mode	No. of ship-ments[a]	Accident frequency (per year)[b]	Accident location: population zone[c]	Maximum individual TEDE[d] (rem)	Maximum individual LCF[e]	Population TEDE[d] (person-rem)	Population LCF[e]
Portland, Oregon to Hanford, Washington	Truck	236	1.23E-07	Urban	2.36E-05	1.18E-08	1.98E-03	9.90E-07
Seattle, Washington to			1.01E-05	Rural	2.36E-05			

Hanford, Washington						1.18E-08	3.65E-06	1.83E-09
Norfolk, Virginia to Hanford, Washington			1.43E-06	Urban	2.36E-05	1.18E-08	1.86E-03	9.3E-07

a. Assumes one cask per truck shipment.
b. Accident frequency based on the number of shipments, campaign duration, one-way shipping distance, and conditional probability.
c. Accident location is based on the population zone where maximum individual dose occurs.
d. TEDE - 50-year total effective dose equivalent.
e. LCF - Latent cancer fatalities. Calculated on dose (rem) to maximum individual or population, i.e., 5.0E-04 LCF/rem.

The calculated dose to the maximally exposed individual and population are shown in Table B-14. The dose to the maximally exposed individual was 8.39E-01 rem and the potential latent cancer fatalities would be 4.20E-04. The accident frequency varies by route and ranges from 1.25E-07 to 1.88E-06/year.

The population doses are also shown in Table B-14. The collective dose ranges from 3.48E+00 to 1.42E+03 person-rem. The potential latent cancer fatalities range from 1.74E-03 to 0.710.

B.4.2.4 Assessment of Nonradiological Impacts. Nonradiological accident impacts consist of fatalities that may result from traffic accidents involving the shipments to and from the offshore processing facility. Nonradiological incident-free impacts are those resulting pollutants emitted from the vehicles. These impacts are not related to the radioactive nature of the materials being transported. In fact, the number of estimated injuries and fatalities would be the same even if the cargo were not radioactive materials. This section uses unit risk factors to estimate the nonradiological impacts associated with the five shipping scenarios considered in this evaluation.

The potential for accidents involving shipments of materials to and from an offshore processing facility is assumed to be comparable to that of general truck, rail, and barge transport in the U.S. Nonradiological accident unit risk factors were taken from Saricks and Kvitek (1994) to calculate nonradiological accident impacts. These risk factors, in units of fatalities-per-km of travel in rural and urban population zones, were multiplied by the total distance traveled in each zone by all of the shipments and then summed to calculate the expected number of nonradiological fatalities. The unit risk factor for travel in suburban zones was represented by the average of the rural and urban unit risk factors given by Saricks and Kvitek (1994).

Impacts to the public from non-radiological causes are also evaluated. This includes fatalities resulting from pollutants emitted from the vehicles during normal transportation. Based on the information contained in Rao et al. (1982), the types of pollutants that are present and can impact the public are sulfur oxides (SOx), particulates, nitrogen oxides (NOx), carbon monoxide (CO), hydrocarbons (HC), and photochemical oxidants (Ox). Of these pollutants, Rao et al. (1982) determined that the majority of the health effects are from SOx and the particulates. Unit risk

Table B-14. Calculated maximum individual and population radiological doses and latent cancer fatalities based on accident location and frequency for solidified high level waste shipments

Transportation Route	Mode	No. of ship-ments.a	Accident frequency (per year)b	Accident location: population zonec	Maximum individual		Population	
					TEDEd (rem)	LCFe	TEDEd (person-rem)	LCFe
Portland, Oregon to Hanford, Washington	Rail	24	3.39E-07	Rural	8.39E-01	4.20E-04	3.48E+00	1.74E-03
Seattle, Washington to Hanford, Washington			1.25E-07	Urban	8.39E-01	4.20E-04	1.42E+03	7.1E-01
Norfolk, Virginia to			1.88E-06	Urban	8.39E-01	4.20E-04	1.37E+03	6.8E-01

Hanford, Washington

a. Assumes one cask per rail shipment.
b. Accident frequency based on the number of shipments, campaign duration, one-way shipping distance, and conditional probability.
c. Accident location is based on population zone where maximum individual dose occurs.
d. TEDE - 50-year total effective dose equivalent.
e. LCF - Latent cancer fatalities. Calculated on dose (rem) to the maximum individual or population, i.e., 5.0E-04 LCF/rem.

factors (fatalities per kilometer) for both truck and rail shipments were developed by Rao et al. (1982) for travel in urban population zones (1.0E-07/km and 1.3E-07/km truck and rail respectively). These unit risk factors were combined with the total shipping distance in urban population zones to calculate the nonradiological incident-free impacts to the public.

The results of the nonradiological accident and incident-free impact calculations for the five potential shipping scenarios are presented in Table B.15. The values reported in the table represent the sum of the impacts from all of the shipments and include the impacts from shipments carrying cargo as well as those from empty return shipments.

B.4.3 Dose to the Public from Port Activities

Normal port activities during transport of N Reactor SNF are not expected to have any consequences for members of the public other than port workers, as discussed in Section 3.3.

The consequences of accidents during port transit were estimated using the same assumptions described for worker consequences in Section 3.3.2. Collective point estimates of risk to the population within 50 miles (80 km) of each location was estimated for an accident at the dock and on the approach to the port. The point estimate of risk to an individual at 1600 m (1 mile) was also estimated for applicable exposure pathways as described in Attachment A of this appendix. Consequences for populations and individuals are reported, both with and without the risk from ingestion of locally grown foods because protective action guidelines would require mitigative actions if the projected dose exceeded specified levels. Individual consequences assume 95% atmospheric dispersion, whereas consequences to populations are estimated for both 50% and 95% atmospheric dispersion.

Table B.15. Nonradiological transportation impacts of offshore processing scenarios

Shipping scenario	Accident impacts, fatalities	Incident-free impacts, fatalities
Barge to Portland	1.1E-02	2.1E-03
Seattle by Truck	8.9E-03	1.2E-03
Seattle by Rail	1.2E-02	3.4E-03
Norfolk by Truck	1.3E-01	1.6E-02
Norfolk by Rail	1.2E-01	1.5E-02

The consequences of port accidents were estimated in a manner similar to that used for overland transportation impacts. The contents of one shipping cask were assumed to be involved in an accident (see Table B-1), with radionuclide releases according to the release fractions reported in Table B-7. The dose and resulting LCF were calculated for each of the six accident severity categories. The point estimates of risk included the consequences as LCF for accidents of each severity category multiplied by the frequency with which an accident of that severity would occur. The accident frequencies for each severity category were assumed to be the overall accident rate per port transit (3.2 x 10-4) multiplied by the conditional probability for accidents in each severity category listed in Table B-6 (DOE 1994). The total accident risk for an individual or population was then estimated as the sum of risks for all accident severity categories. Risks for accidents evaluated at 95% (stable) atmospheric dispersion were assumed to be 10% lower than those at 50% (neutral) dispersion.

The results for accidents at the four representative ports are shown in Table B-16, with estimated risks for individual residents and populations within 80 km (50 miles). Point estimates of risk for the individual resident ranged from 6.2 x 10-13 to 1.3 x 10-11 LCF if no locally grown food were considered; results for all exposure pathways including ingestion were 3.5 x 10-11 to

7.8 x 10-10 LCF.

Collective point estimates of risk to the population within 50 miles of Portland, Oregon were 5.2 x 10-9 to 4.9 x 10-6 LCF assuming 50% atmospheric dispersion conditions and 1.0 x 10-8 to 8.3 x 10-6 LCF for 95% atmospheric dispersion. Corresponding results for the population in the vicinity of Newark are 2.3 x 10-8 to 4.9 x 10-5 LCF assuming 50% atmospheric dispersion and 1.5 x 10-8 to 8.4 x 10-5 LCF for 95% atmospheric dispersion. Consequences for the collective populations of Seattle-Tacoma and Norfolk fell between the estimates for the other two ports.

The maximum reasonably foreseeable accident was a category 6 accident, which has a frequency of 1.3 x 10-7 per port transit, and which was evaluated for either neutral or stable atmospheric conditions resulting in a cumulative frequency of 2.2 x 10-6 or 2.2 x 10-7, respectively for 17 SNF shipments. Dose and risk estimates for the maximum reasonably foreseeable accident are presented in Table B-17. The dose to the resident member of the public ranged from an estimated 0.02 to somewhat over 1 rem for all ports, depending on whether locally grown food was considered as an exposure pathway. The corresponding probability of LCF ranged from 9.0 x 10-6 to 6.5 x 10-4 and point estimates of risk, from 2.0 x 10-12 to 1.4 x 10-10 LCF. The collective consequences to the populations within 80 km (50 mi) of the ports

Table B-16. Point estimate of risk[a] of latent cancer fatalities from port accidents.

Port location	Portland, Oregon		Seattle-Tacoma, Washington		Norfolk, Virginia		Newark, New Jersey	
Exposure Pathways	All pathways	Inhalation + external	All pathways	Inhalation + external	All pathways	Inhalation + external	All pathways	Inhalation + external
Individual at 1600 m - 95% (stable) atmospheric conditions								
1 Shipment	4.6E-11	7.9E-13	3.5E-11	6.2E-13	4.6E-11	7.9E-13	3.9E-11	6.8E-13
17 Shipments	7.8E-10	1.3E-11	6.0E-10	1.0E-11	7.8E-10	1.3E-11	6.7E-10	1.2E-11
Population within 80 km (50 miles) of dock - 50% (neutral) atmospheric conditions								
1 Shipment	2.9E-07	6.6E-09	1.9E-07	4.3E-09	1.2E-07	2.7E-09	1.0E-06	2.3E-08
17 Shipments	4.9E-06	1.1E-07	3.2E-06	7.2E-08	2.0E-06	4.6E-08	1.7E-05	3.9E-07
Population within 80 km (50 miles) of harbor approach - 50% (neutral) atmospheric conditions								
1 Shipment	2.4E-07	5.2E-09	6.0E-08	1.4E-09	1.1E-07	2.5E-09	2.9E-06	6.5E-08
17 Shipments	4.0E-06	8.9E-08	1.0E-06	2.3E-08	1.9E-06	4.3E-08	4.9E-05	1.1E-06
Population within 80 km (50 miles) of dock - 95% (stable) atmospheric conditions								
1 Shipment	4.5E-07	1.0E-08	2.3E-07	5.1E-09	3.3E-07	7.4E-09	5.0E-06	1.5E-08
17 Shipments	7.6E-06	1.8E-07	3.9E-06	8.8E-08	5.6E-06	1.3E-07	8.4E-05	2.5E-07
Population within 80 km (50 Miles) of Harbor Approach - 95% (stable) Atmospheric Conditions								
1 Shipment	4.9E-07	1.0E-08	1.2E-07	2.8E-09	2.5E-07	5.8E-09	4.9E-06	1.1E-07
17 Shipments	8.3E-06	1.7E-07	2.0E-06	4.7E-08	4.3E-06	9.8E-08	8.3E-05	1.9E-06

a. Point estimate of risk is defined as the consequences to the receptor or population (as LCF) of an accident of a given severity category (assuming the accident occurs), multiplied by the frequency per shipment with which an accident of that severity would occur. The risks for accidents of all severity categories are then summed to obtain the total risk per shipment.

ranged from 2.0 x 10-3 to 380 LCF assuming the accident occurs, depending on the location of the accident (port or harbor approach) and the exposure pathways considered. The corresponding point estimates of risk for latent fatal cancers amounted to 4.4 x 10-9 to 8.2 x 10-5.

B.4.4 Dose to the Public from Ocean Transport to the United Kingdom

This analysis expects no dose to members of the public resulting from incident-free ocean transport of N Reactor SNF to the U.K. The ships carrying the fuel are owned and operated by the commercial vendor, and its shipboard crews are assumed to be classified as radiation workers for the purposes of this analysis.

The effects of losing a cask at sea are estimated to be comparable to those evaluated for shipment of foreign research reactor SNF to the U.S. (DOE 1994), based on similar shipping inventories of long-lived radionuclides per cask. The maximum dose to an individual for a cask lost in coastal waters was expected to be 11 mrem/year if the cask were left in place until all its contents dispersed. The corresponding consequences to marine biota were 0.24 mrad/year for fish, 0.32 mrad/year for crustaceans, and 13 mrad/year for mollusks. The consequences resulting from loss of a cask in the deep ocean would be many orders of magnitude lower than estimates for coastal waters.

The probability of accident on the open ocean was estimated to be 4.6 x 10-5 per shipment for an average duration voyage of about 20 days in transporting SNF from foreign research reactors to the U.S. (DOE 1995). The frequency of accidents for overseas shipment of SNF and process materials via special-purpose ships would likely be within a factor of two or three of this estimate. However, that frequency applies to commercial freight shipping experience, and it is possible that the use of special-purpose ships could result in a different accident rate. Using the commercial freight accident rate given above, the probability of an accident on the open ocean involving transport of SNF (17 ocean shipments), HLW (1 shipment), uranium oxide (1 shipment), and plutonium oxide (1 shipment) was calculated to be about 9.2E-04, integrated over all the shipments.

Table B-17. Consequences and risk to the public surrounding port facilities from maximum reasonably foreseeable accidents involving SNF shipments at or near the ports.

Port Location	Portland, Oregon		Tacoma, Washington		Norfolk, Virginia		Newark, New Jersey	
	All pathways	Inhalation + external	All pathways	Inhalation + External	All pathways	Inhalation + external	All pathways	Inhalation + external
Resident at 1600 m								
Dose (rem)	1.3E+00	2.3E-02	9.9E-01	1.8E-02	1.3E+00	2.3E-02	1.1E+00	2.0E-02
LCF	6.5E-04	1.2E-05	5.0E-04	9.0E-06	6.5E-04	1.2E-05	5.5E-04	9.9E-06
LCF risk	1.4E-10	2.5E-12	1.1E-10	2.0E-12	1.4E-10	2.5E-12	1.2E-10	2.2E-12
Population within 80 km (50 mi) of dock - 50% (neutral) atmospheric dispersion								
Dose (person-rem)	8.7E+02	1.9E+01	5.5E+02	1.2E+01	3.5E+02	7.7E+00	3.1E+03	6.8E+01
LCF	4.4E-01	9.7E-03	2.8E-01	6.0E-03	1.8E-01	3.9E-03	1.6E+00	3.4E-02
LCF risk	9.5E-07	2.1E-08	6.0E-07	1.3E-08	3.8E-07	8.4E-09	3.4E-06	7.3E-08
Population within 80 km (50 mi) of harbor approach - 50% (neutral) atmospheric dispersion								
Dose (person-rem)	6.9E+02	1.5E+01	1.8E+02	4.0E+00	3.3E+02	7.3E+00	8.5E+03	1.8E+02
LCF	3.5E-01	7.5E-03	9.0E-02	2.0E-03	1.7E-01	3.7E-03	4.3E+00	9.1E-02
LCF risk	7.5E-07	1.6E-08	2.0E-07	4.4E-09	3.6E-07	7.9E-09	9.2E-06	2.0E-07
Population within 80 km (50 mi) of dock - 95% (stable) atmospheric dispersion								
Dose (person-rem)	1.3E+04	2.9E+02	6.9E+03	1.5E+02	9.8E+03	2.1E+02	7.5E+05	1.7E+03
LCF	6.5E+00	1.4E-01	3.5E+00	7.5E-02	4.9E+00	1.1E-01	3.8E+02	8.6E-01
LCF risk	1.4E-06	3.1E-08	7.5E-07	1.6E-08				

					1.1E-06	2.3E-08	8.2E-05	1.9E-07
Population within 80 km (50 mi) of harbor approach - 95% (stable) atmospheric dispersion								
Dose (person-rem)	1.4E+04	3.1E+02	3.6E+03	7.8E+01	7.5E+03	1.6E+02	1.4E+05	3.2E+03
LCF	7.0E+00	1.6E-01	1.8E+00	3.9E-02	3.8E+00	8.0E-02	7.0E+01	1.6E+00
LCF risk	1.5E-06	3.4E-08	3.9E-07	8.5E-09	8.2E-07	1.7E-08	1.5E-05	3.5E-07

B.5 Legal and Policy Considerations

B.5.1 Policy Considerations

For a general discussion of the policy considerations associated with DOE's management of SNF, see Section 2 of Volume 1. Several policy considerations bear on the evaluation of international shipment and processing of SNF.

The primary consideration in international shipment of nuclear materials is concern for unauthorized diversion of such materials to foreign weapons programs (nuclear proliferation). This concern is mitigated, but not eliminated, because SNF is not directly useable in simple nuclear weapons. Stringent safeguards exist for overseas transportation of nuclear materials. Highly enriched uranium has been transported overseas for research purposes, and SNF from research reactors has been returned to the U.S. for disposition. Although such return shipments have not occurred routinely since 1988, DOE is considering resumption of such shipments in support of U.S. efforts to remove highly enriched uranium SNF from international commerce. Two such shipments were completed on an urgent relief basis in 1994, and additional shipments may resume on completion of an evaluation by DOE (1995).

DOE (1993) has evaluated the safety and policy issues associated with overseas transport of plutonium and concluded that such shipments could be made safely and securely within the context of current national and international regulations for transport of radioactive materials (including special nuclear materials). The report (DOE 1993) addresses risks to the public and the environment, emergency response requirements, safeguards, and the regulatory framework within which such shipments could be made.

The overseas transportation of SNF and eventual return of vitrified wastes and end products contemplated in this alternative would be managed in accordance with well defined and demonstrated practices. However, a decision to implement the overseas transportation and processing option will require close examination of various policy and international documents that address plutonium stockpiling and the exchange of nuclear materials.

Other major policy considerations are the comparative risk of overseas shipment and return versus strictly domestic transportation and management of SNF and the involvement of a foreign population and environment in the foreign processing alternative. A decision to implement the BNFL option would be likely to generate controversy over the perception of transferrring environmental problems overseas. Transportation risks are addressed in Sections B.3 and B.4 of this attachment.

The representative facility used for this analysis (British Nuclear Fuels facility operations in Sellafield, U.K.) began in the 1940s with the same primary mission as Hanford. This commercial facility processes large volumes of SNF from several foreign countries. Round trip shipments and management of SNF and waste products would therefore be undertaken within a demonstrated regulatory, technical, and physical infrastructure.

B.5.2 Applicable Laws, Regulations, and Other Requirements

B.5.2.1 General. This discussion is limited to regulatory considerations associated with the

round trip domestic and overseas transportation of SNF and other hazardous and radioactive materials. For a discussion of general laws and regulation governing the management of SNF, see Section 2.2 of this appendix. State and local requirements will not be discussed here because the shipments of SNF under consideration would be in interstate or foreign commerce and federal provisions would govern. Internal DOE Orders also are not discussed.

The significant international and federal laws and regulations that apply to the transportation of hazardous and radioactive materials include the following laws:

- International Convention on the Safety of Life at Sea of 1960 (as amended)
- Atomic Energy Act (42 U.S.C. 2011 et seq.)
- Hazardous Transportation Materials Act (49 U.S.C. 1801 et seq.)
- Resource Conservation and Recovery Act, as amended by the Hazardous and Solid Waste Amendments (42 U.S.C. 26901 et seq.)
- Executive Order 12898 (Environmental Justice)
- Executive Order 12114 (Environmental Effects Abroad of Major Federal Actions).

B.5.2.2 Domestic Packaging and Transportation. Transportation of hazardous and radioactive

materials, substances, and wastes are governed by the regulations of the U.S. Department of Transportation (DOT) (49 CFR 171-178, 383-397), the U.S. Nuclear Regulatory Commission (NRC) (10 CFR 71), and the U.S. Environmental Protection Agency (EPA) (40 CFR 262, 265).

United States DOT regulations contain requirements for identifying a material as hazardous or radioactive. These regulations interface with NRC and EPA regulations for identifying material, but the DOT regulations govern hazard communication via placarding, labeling, reporting, and shipping requirements (see especially 10 CFR 71.5, in which DOT regulations are applied to shipping of radioactive materials by NRC regulations).

Nuclear Regulatory Commission regulations address packaging design and certification requirements. Certification is based on safety analysis report data on the packaging design for various hypothetical accident conditions.

General overland carriage is governed by specific regulations dealing with packaging notification, escorts, and communication. There are specific provisions for truck and for rail. For carriage by truck, the carrier must use interstate highways or state-designated preferred routes. Department of Transportation regulations found in 49 CFR 397.101 establish routing and driver training requirements for highway carriers of packages containing "highway-route-controlled quantities" of radioactive materials. Spent nuclear fuel shipments constitute such controlled shipments. For carriage by rail car, each shipment by the railroad must comply with 49 CFR 174 Subpart K "Detailed Requirements for Radioactive Materials."

B.5.2.3 Overseas Transportation. To the extent feasible, the NRC and DOT conform their

regulations to the model regulations of the International Atomic Energy Agency. These model international regulations are also incorporated into the International Maritime Dangerous Goods Code, which was developed to supplement the International Convention on the Safety of Life at Sea, to which the U.S. is a signatory. Transportation risk in the global commons must be evaluated in accordance with Executive Order 12114 (Environmental Effects Abroad of Major Federal Actions).

Transportation of dangerous cargoes through the Panama Canal is governed by the International Maritime Dangerous Goods Code (IMDG) and is addressed in 35 U.S.C. 113. General provisions for passage through the Panama Canal are found at 35 U.S.C. 101-135. General regulations governing navigation, including the applicability of the International Regulations for the Prevention of Collisions at Sea (1972), are found throughout Title 33 of the CFRs.

Relevant regulations applying to transport of SNF by vessel are found in 10 CFR Parts 71 and 73 (NRC) and 49 CFR Part 176 (DOT). These regulations address prenotification to the U.S. Coast Guard for inspection, and provide specifications for packaging, labelling, and other preparation for shipment. A Certification of Competent Authority must be obtained in compliance with International Atomic Energy Agency requirements. Specific provisions are made for stowage, including package surface temperature limitations, spacing, and total aggregate volume and number of freight containers.

B.6 Environmental Justice

For analytical purposes, three modes of transportation were selected for evaluation: 1) truck or rail to a port on Puget Sound (such as Tacoma, Washington); 2) barge to a Columbia River port in the vicinity of Portland, Oregon; or 3) rail or truck across the country to an East Coast port. The East Coast port of reference was assumed to be Norfolk, Virginia (Hampton Roads). These three modes are considered to provide a reasonable range of ports and transportation options for evaluation.

The DOE draft Environmental Impact Statement on the Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor (FRR) Spent Nuclear Fuel (DOE/EIS-0218D) provides information on the numbers and spatial locations of minority and low-income populations surrounding the ports of interest identified above and the Hanford Site. Because the FRR EIS (see Section A.2) utilized somewhat different analytical methodologies for environmental justice purposes than those utilized in this document, some data may vary. The reasons for such variations are explained in Section L-3.5 of Appendix L of this document. Utilizing demographic data entirely from the FRR EIS for the purposes of this attachment, allows for comparison of the sites of interest under consistent definitions and assumptions because the ports identified above were not demographically evaluated in Appendix L of this EIS. The reader is referred to the draft FRR EIS for maps locating the spatial distribution of minority and low income populations.

Table B-18 lists information on selected populations of interest for regions surrounding the Hanford loading facility and ports. Regions surrounding each port are areas that lie at least partially within a 16-km (10-mile) radius of the port. Eighty kilometers (50 miles) is used for Hanford. Population characteristics shown in the table were extracted from detailed, block-group statistical population data of the 1990 census. A block group usually includes 250 to 550 housing units.

Because the impacts as a result of transportation and facility operations are small and reasonably foreseen accidents present no significant risk, no reasonably foreseeable adverse impacts have been identified to the surrounding population. Therefore, no disproportionately high and adverse effects would be expected for any particular segment of the population, including minority and low-income populations.

Table B-18. Characterization of populations residing near candidate facilities (Hanford Site and candidate ports of embarkation[a]).

Facility	Total population within 16 km of facility	Total minority populati within 16 km of facilit		Households within 16 km of facility	Low income households within 16 km of facility	
	Number	Number	Percent	Number	Number	Percent
Hanford, Washington[c]	383,934	95,042	24.8	136,496	57,667	42.2
Tacoma, Washington	511,575	85,341	16.7	198,458	83,101	41.9
Portland, Oreg	356,064	54,704	15.4	146,047	66,186	45.3
Norfolk, Virgi	681,864	300,179	44.0	206,464	90,723	43.9

a. Data based on draft FRR EIS (DOE/EIS-0218D).

b. Hispanic origin individuals can be of any race.

c. In the case of the Hanford loading facility, a radius of 80 km rather than 16 km was used to define the nearby population.

B.7 Cost

The cost estimate for the foreign processing option, as provided by the representative facility, includes the full service of transporting the SNF from the Hanford Site to the U.K. facility, processing the material into recovered uranium and plutonium and HLW, packaging these products appropriately for return to the U.S., storing the packaged materials pending shipment, and transporting the materials back to the U.S. (BNFL 1994). The proposal provides only a range of total cost ($1.3 - $2 billion), with no breakdown of those costs into the principal cost elements. Thus, there is no detailed estimate of costs for the individual parts of the full service package. The above estimate does not include costs incurred at Hanford to package and stabilize the fuel, if necessary, prior to shipment, or to manage degraded fuel and sludge that may not be suitable for overseas shipment.

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APPENDIX B Idaho National Engineering Laboratory Spent Nuclear Fuel Management Program

Department of Energy Programmatic
Spent Nuclear Fuel Management
and
Idaho National Engineering Laboratory
Environmental Restoration and
Waste Management Programs
Final Environmental Impact Statement
Volume I
Appendix B
idaho National Engineering Laboratory
Spent Nuclear Fuel Management Program
April 1995
U.S. Department of Energy
Office of Environmental Management
Idaho Operations Office

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1. INTRODUCTION

The U.S. Department of Energy (DOE) has prepared the Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement (SNF and INEL EIS) to assist its management in making two decisions. The first decision, which is programmatic, is to determine the management program for DOE spent nuclear fuel. The second decision is on the future direction of environmental restoration, waste management, and spent nuclear fuel management activities at the Idaho National Engineering Laboratory.

Volume 1 of the EIS, which supports the programmatic decision, considers the effects of spent nuclear fuel management on the quality of the human and natural environment for planning years 1995 through 2035. DOE has derived the information and analysis results in Volume 1 from several site-specific appendixes. Volume 2 of the EIS, which supports the INEL-specific decision, describes environmental impacts for various environmental restoration, waste management, and spent nuclear fuel management alternatives for planning years 1995 through 2005.

This Appendix B to Volume 1 considers the impacts on the INEL environment of the implementation of various DOE-wide spent nuclear fuel management alternatives. The Naval Nuclear Propulsion Program, which is a joint Navy/DOE program, is responsible for spent naval nuclear fuel examination at the INEL. For this appendix, naval fuel that has been examined at the Naval Reactors Facility and turned over to DOE for storage is termed naval-type fuel. This appendix evaluates the management of DOE spent nuclear fuel including naval-type fuel. Naval spent nuclear fuel examination is addressed in Appendix D; Section 5.16 of this appendix includes relevant environmental consequences from Appendix D.

In addition to this introduction, Appendix B contains the following chapters:

- Chapter 2 - Background: Describes INEL spent nuclear fuel facilities, the regulatory framework for spent nuclear fuel management at the INEL, and the INEL spent nuclear fuel management program.
- Chapter 3 - Spent Nuclear Fuel Management Alternatives: Describes the DOE-wide spent nuclear fuel management alternatives as the INEL would implement them, and provides a summary comparison of potential environmental consequences for each alternative, as described in Chapter 5.
- Chapter 4 - Affected Environment: Describes the INEL site and the surrounding environment that DOE spent nuclear fuel management actions could affect.
- Chapter 5 - Environmental Consequences: Provides the results of environmental consequence analyses for each spent nuclear fuel management alternative.
- Chapter 6 - References

Volume 1 contains a list of acronyms and abbreviations and a glossary that is applicable to this appendix.

2. BACKGROUND

This chapter contains an overview of the Idaho National Engineering Laboratory (INEL) facilities and historic events related to spent nuclear fuel, a description of the regulatory framework for the actions evaluated in this document, and an overview of the current spent nuclear fuel management program at the INEL.

2.1 Overview

The following sections provide a general overview of the INEL including its history, current activities, and mission as they relate to spent nuclear fuel management and future decisions.

2.1.1 History of Spent Nuclear Fuel Activities

The U.S. Atomic Energy Commission, a predecessor of the U.S. Department of Energy (DOE), established the INEL, formerly the National Reactor Testing Station, to build, test, and operate various types of nuclear reactors, support plants, and associated equipment. Since its establishment in 1949 (see Table 2-1), DOE and its predecessor agencies have built 52 reactors at the INEL. The major DOE programs at the site have included test irradiation services, uranium recovery from highly enriched spent fuels, calcination of liquid radioactive waste, light-water-cooled reactor safety testing and research, operation of research reactors, environmental restoration, and storage and surveillance of solid transuranic wastes. In support of the DOE reactor research program and as part of the spent nuclear fuel reprocessing program, the INEL has received spent nuclear fuel from more than 30 offsite sources, including naval reactors, university reactors, commercial reactors, and DOE research reactors, as well as fuels fabricated in the United States and irradiated in foreign reactors (DOE 1993).

The Experimental Breeder Reactor-I, now a National Historic Landmark, maintains a key place in the history of nuclear power in the United States. In December 1951, this reactor generated the first usable electricity from a nuclear reactor. The Experimental Breeder Reactor-I also demonstrated that a nuclear reactor could actually produce more fuel than it consumes.

Of special significance to spent nuclear fuel is the history of the Idaho Chemical Processing Plant. From 1953 to 1992, this plant recovered usable uranium from spent nuclear fuel from United States government reactors. The plant operated for 39 years as a full-scale production facility. But in April 1992, DOE decided to phase out reprocessing for material recovery, resulting in the shutdown of the reprocessing operation.

Table 2-1. INEL spent nuclear fuel history.

Year	Event
1949	National Reactor Testing Station established
1951	Site reactor first to generate electricity from nuclear fission
1953	ICPPa began operation
1953	Test of first submarine nuclear reactor
1957	Expended Core Facility constructed
1965	DOE contract with Public Service Company of Colorado (Fort St. Vrain)
1974	Site became Idaho National Engineering Laboratory
1980	DOE contracted to receive Public Service Company of Colorado (Fort St. Vrain) spent nuclear fuel
1992	Decision to discontinue reprocessing of spent nuclear fuel at ICPPa announced
1992	DOE creates Office of Spent Fuel Management
1993	Court order of June 28, 1993 issued

a. ICPP = Idaho Chemical Processing Plant.

Spent naval nuclear fuel handling at the Naval Reactors Facility originated in 1957 with the construction of the Expended Core Facility. The original building contained a water pit and shielded cells, which are connected to the water pit by transfer tunnels. The Expended Core Facility examines spent nuclear fuel from operating naval ships and from prototype naval reactors. The examinations support research and development for naval fuel quality improvement. Over the years, the Navy made additions and improvements at the Naval Reactors Facility site, including the construction and operation of three prototype reactors and facilities for training naval nuclear powerplant operators. The Naval Nuclear Propulsion Program is placing the prototype reactors, which have reached the ends of their useful lives, in layup. All training is expected to end before DOE issues the Record of Decision for this Environmental Impact Statement (EIS). Expended Core Facility activities are continuing. Appendix D describes the Naval Reactors Facility in more detail.

In 1965 the United States entered into a contract with Public Service Company of Colorado, with which the United States agreed to lease special nuclear material to Public Service Company of Colorado for fuel at the Fort St. Vrain Nuclear Power Plant. In 1980, the United States and Public Service Company of Colorado modified the 1965 contract, requiring DOE to accept returned Fort St. Vrain spent nuclear fuel at the INEL. From 1980 to 1986, Public Service Company of Colorado made approximately 120 shipments of Fort St. Vrain spent nuclear fuel to the INEL.

In 1974 the National Reactor Testing Station became the Idaho National Engineering Laboratory. The INEL mission broadened to include research and engineering for nonnuclear programs and environmental restoration and waste management activities.

In the early 1980s, pursuant to the West Valley Demonstration Project Act (42 USC 2021a) and a court order, DOE agreed to accept 125 special case commercial reactor spent nuclear fuel assemblies located at the state-owned Western New York Nuclear Service Center. DOE began a project to demonstrate the viability of a transportable spent nuclear fuel storage cask, with the intention of shipping the fuel to the INEL. Based on this, New York State Energy Research and Development Authority, which has jurisdiction over the center, has allowed continued storage until DOE obtained U.S. Nuclear Regulatory Commission Certificates of Compliance, which have been issued. The fuel remains at West Valley awaiting the Record of Decision for this EIS.

In addition to the naval and INEL-generated fuel on the site, some special-case spent nuclear fuel, such as fuel from university reactors, has been shipped directly to the Idaho Chemical Processing Plant for storage. Damaged fuel from the 1979 Three Mile Island accident was shipped directly to Test Area North for examination and storage as part of a research mission.

In 1990, DOE issued an Environmental Assessment and Finding of No Significant Impact for

Public Service Company of Colorado shipments of Fort St. Vrain spent nuclear fuel to the INEL. The State of Idaho challenged the adequacy of the Environmental Assessment and, in June 1993, the United States District Court for the District of Idaho found for the State and ordered DOE to prepare this EIS. A DOE appeal of the order resulted in a December 1993 amendment that governs the DOE schedule and obligation for preparing the EIS.

2.1.2 Current Activities at Spent Nuclear Fuel-Related Facilities

Six major facility areas at the INEL (Figure 2-1) store spent nuclear fuel: Argonne National Laboratory - West, Idaho Chemical Processing Plant, Naval Reactors Facility, Power Burst Facility, Test Area North, and Test Reactor Area. Spent fuel at the INEL is kept in a variety of dry and wet configurations. The total amount of spent nuclear fuel at the INEL accounts for about 10 percent (by weight of heavy metal) of the spent nuclear fuel in the DOE complex (DOE 1993).

Figure 2-1. Major facility areas located at the Idaho National Engineering Laboratory site.

Table 2-2 lists the primary INEL spent nuclear fuel storage facilities, the types of fuel in storage, and the storage configurations. Figure 2-2 indicates the relative proportion of fuel at these facilities. The number and variety of wet and dry storage configurations currently in use at the INEL is largely the result of the different purposes for the facilities (e.g., at-reactor storage, storage research and development, reprocessing, and fuel research and development). The condition of the spent nuclear fuel in storage is generally good with the notable exception of the fuel in the Underwater Fuel Storage Facility (CPP-603). The following paragraphs briefly describe each primary facility area that manages spent nuclear fuel.

The Argonne National Laboratory - West generates spent nuclear fuel as a result of research and development activities related to advanced reactor design. DOE has brought small quantities of spent nuclear fuel from other reactors to this facility to support these activities. Reactors at Argonne National Laboratory - West are the Experimental Breeder Reactor II, the Transient Reactor Test Facility, the Zero Power Physics Reactor, and the Neutron Radiography Reactor. Storage facilities include both wet (including molten sodium) and dry configurations.

The Idaho Chemical Processing Plant historically received spent nuclear fuel from many onsite and offsite reactors for reprocessing (i.e., the recovery of uranium for reuse). However, DOE decided to phase out reprocessing activities in 1992. The new mission for this facility area is receipt and storage, plus research and development of technologies in support of the disposition of spent nuclear fuel. The Idaho Chemical Processing Plant stores virtually all types of spent nuclear fuel except production reactor fuel [i.e., fuel from Hanford Site and Savannah River Site (SRS) production reactors]. It stores nonproduction aluminum-based spent nuclear fuel. This facility uses both wet and dry storage configurations.

The Naval Reactors Facility includes the Expended Core Facility, which receives and examines naval spent nuclear fuel to support fuel development and performance analyses. In addition, the Expended Core Facility removes structural support material from fuel assemblies before the transfer of the fuel portion to the Idaho Chemical Processing Plant for interim storage.

Table 2-2. Major INEL spent nuclear fuel storage facilities.

Facility(a)	Storage Type(b)	Fuel Type(c)							
		1	2	3	4	5	6a	6b	6c
Argonne National Laboratory - West									
Experimental Breeder Reactor II	Liquid sodium						-		
Hot Fuel Examination Facility	Dry						-		
Neutron Radiography Reactor	Wet						-		
Radioactive Scrap and Waste Facility	Dry						-		
Transient Reactor Test Facility	Dry							-	
Idaho Chemical Processing Plant									
Underwater Fuel Storage Facilityd	Wet	-	-				-	-	
Irradiated Fuel Storage Facility	Dry				-				
Fuel Storage Area/Fluorinel Dissolution	Wet	-	-				-	-	

Process Cell							
Underground Storage Facility	Dry			-			
Naval Reactors Facility							
Expended Core Facility	Wet	-			-		
Expended Core Facility Rail Siding	Dry	-					
Power Burst Facility							
Power Burst Facility Storage Canal	Wet					-	
Test Reactor Area							
Materials Test Reactor Canal	Wet				-		-
Advanced Reactivity Measurement Facility	Wet		-				
Coupled Fast Reactivity Measurement Facility	Wet		-				
Advanced Test Reactor Canal	Wet		-				
Test Area North							
Test Area North Pool	Wet				-		
Test Area North Pad	Dry				-		

a. This table lists the major spent fuel storage facilities. Other facilities (e.g., laboratories) might periodically contain small quantities of spent nuclear fuel.

b. Wet storage involves water-filled pools. Dry storage involves a variety of configurations (e.g., casks, wells, buildings).

c. The spent fuel types are as follows:

1. Naval-type fuel
2. Savannah River Site production fuels and other aluminum-clad fuels
3. Hanford Site production fuels
4. Graphite fuels
5. Special case commercial fuels

6a. Experimental reactors - stainless steel-clad fuels
6b. Experimental reactors - zirconium-clad fuels
6c. Experimental reactors - other fuel configurations

d. Spent nuclear fuel storage at this facility will cease by December 31, 2000, as part of an agreement between DOE and the State of Idaho.

Figure 2-2. Distribution of INEL SNF. The Power Burst Facility reactor was placed in operational standby in 1992. A limited amount of spent nuclear fuel from this facility remains in wet storage, in a storage pool that is in good condition, but it is small and uneconomical to use. DOE plans to remove the fuel from this facility by 1996.

DOE has used Test Area North for commercial reactor fuel research. The large Test Area North Hot Shop and Hot Cells have supported the Loss of Fluid Test and commercial nuclear fuel testing, including dry cask storage demonstration. Test Area North stores special case commercial fuel (including Three Mile Island Unit 2 core debris) and DOE experimental fuel similar to commercial nuclear fuel.

Test Reactor Area has historically operated a number of test reactors, but the Advanced Test Reactor and its associated Critical Facility are the only reactors now operating. Most spent nuclear fuel at this area is associated with the Test Reactor Area reactors, which utilized aluminum-based fuels. In addition, DOE stores small amounts of special case commercial, foreign, and Power Burst Facility spent nuclear fuel at Test Reactor Area in the Materials Test Reactor basin. All spent nuclear fuel in storage at the Test Reactor Area is in water-filled pools (DOE 1993).

2.1.3 Spent Nuclear Fuel Mission

The INEL spent nuclear fuel mission is to manage DOE-owned spent fuel cost-effectively and in a way that protects the safety of INEL workers, the public, and the environment. As the lead laboratory for the DOE Spent Nuclear Fuel Program, the INEL provides support to the Office of Spent Fuel Management and coordinates the development of an integrated program for DOE.

The main focus of near-term activities is the accurate quantification and characterization of DOE-owned spent nuclear fuel, identification of spent nuclear fuel management facilities and their conditions, identification of safe interim storage for existing and new spent nuclear fuel, and identification of technologies and requirements to place DOE spent nuclear fuel in safe interim storage.

Long-term activities include the development of final waste acceptance criteria requirements and stabilization technologies for alternate fuel disposition, construction of facilities to stabilize fuel to meet waste disposal requirements, processing of the fuel to a final waste form, and transportation of the waste form for disposition.

2.2 Regulatory Framework for Spent Nuclear Fuel Management

This section summarizes State of Idaho laws and regulations that apply to spent nuclear fuel management at the INEL. Volume 1, Section 7.2, provides summary information for Federal laws and regulations, Executive Orders, and DOE Orders. Volume 2, Chapter 2, provides information on National Environmental Policy Act reviews related to site-specific decisions that have potential environmental impacts. Volume 2, Chapter 7, provides information on regulatory permits that the INEL holds or for which it has applied.

The Idaho Environmental Protection and Health Act (Idaho Code, Title 39, Chapter 101 et seq.) establishes general provisions for the protection of the environment and public health. The Act created the Idaho Department of Health and Welfare and its Division of Environmental Quality, thereby consolidating all state public health and environmental protection activities in one department. The Act authorizes the Department to promulgate standards, rules, and regulations related to water and air quality, noise reduction, and solid waste disposal; and grants authority to issue required permits, collect fees, establish compliance schedules, and review plans for the construction of sewage and public water treatment and disposal facilities.

The Idaho Water Pollution Control Act (Idaho Code, Title 39, Chapter 36) authorizes the Department of Health and Welfare to protect the waters of Idaho. This law contains general language on the prevention of water pollution and the provision of financial assistance to municipalities.

The Idaho Department of Health and Welfare is also responsible for the enforcement and implementation of the Hazardous Waste Management Act of 1983, as amended (Idaho Code, Title 39, Chapter 44), which provides for the protection of health and the environment from the effects of improper or unsafe management of hazardous wastes and for the establishment of a tracking or manifesting system for these wastes. This program is intended to be consistent with, and not more stringent than, the Federal regulations established under the Resource Conservation and Recovery Act (RCRA). At this time, Idaho has primacy over hazardous and mixed waste regulations promulgated through July 1, 1990, by the U.S. Environmental Protection Agency. The Hazardous Waste Management Act sets forth requirements for the development of plans that address the identification of hazardous wastes; unauthorized treatment, storage, release, use, or disposal of these wastes; and permit requirements for hazardous waste facilities. Under the authority of this Act, the Idaho Department of Health and Welfare has promulgated rules and regulations on the transportation, monitoring, reporting, and record keeping of hazardous wastes.

Several INEL facilities have air quality permits from the State, and operate in compliance with permit conditions. Permit applications are currently pending with the State for proposed new or modified emission sources. In April 1991 DOE submitted an inventory of all potential INEL radioactive and criteria pollutant emission sources to the State. The inventory contains the information necessary for the State to issue the INEL a Permit to Operate.

The Idaho Department of Health and Welfare, Division of Environmental Quality, Air Quality Bureau, conducts annual inspections of the INEL to determine if the operating portions of the site are in compliance with the Rules for the Control of Air Pollution in Idaho. The most recent inspections were in January 1994. In addition, pursuant to 40 CFR Part 61.94(H), DOE submits to the State an annual report documenting compliance with National Emission Standards for Hazardous Air Pollutants at the INEL.

2.3 Spent Nuclear Fuel Management Program at the INEL

In 1992 the Secretary of Energy directed the Assistant Secretary for Environmental Restoration and Waste Management to develop an integrated, long-term spent nuclear fuel management program. In response to this request, DOE created the Office of Spent Fuel Management (EM-37). This office, which has strategic programmatic responsibilities, has designated the INEL as the program support organization for the DOE Spent Nuclear Fuel Program. In this role, the INEL provides technical support to the Office of Spent Fuel Management and develops site communication and integration for the national program.

As identified in the Spent Fuel Working Group Report on Storage of the Department's Spent Nuclear Fuel and Other Reactor Irradiated Nuclear Materials and Their Environmental, Safety and Health Vulnerabilities, Volume I (DOE 1993), some of the current storage facilities at the INEL are inadequate for extended interim storage, and additional storage facilities or modifications might be necessary. In February 1994, DOE issued, Plan of Action to Resolve Spent Nuclear Fuel Vulnerabilities, Phase I (DOE 1994a), followed by a Phase II Plan in April 1994 (DOE 1994b) and a Phase III Plan in October 1994 (DOE 1994c), which identified specific corrective actions to address the spent nuclear fuel vulnerabilities. At the INEL, many of the corrective actions have been completed or are currently underway. The spent nuclear fuel storage pools at Test Area North, Power Burst Facility, and the Underwater Fuel Storage Facility do not comply with new facility regulatory requirements. The INEL plans to move spent nuclear fuel from the CPP-603 Underwater Fuel Storage Facility by December 31, 2000. To stabilize this fuel for storage, the INEL also plans to install canning equipment in the Irradiated Fuel Storage Facility hot cell. This equipment is scheduled for operation by late 1995. To the extent of its existing capability, DOE could consolidate spent nuclear fuel at the Power Burst Facility, the Idaho Chemical Processing Plant, and the Test Area North at the Idaho Chemical Processing Plant as a result of implementing the management alternatives described in Chapter 3. These activities and other planned actions for which National Environmental Policy Act review will be completed before the Record of Decision of this EIS were analyzed under the No-Action Alternative (see Chapter 3).

Each of the specific INEL spent nuclear fuel Plan of Action projects could result in emissions, worker exposures, and other potential environmental impacts. The potential environmental impacts that could result from each project or corrective action item were not analyzed individually but were collectively enveloped by the spent nuclear fuel management activities reported and analyzed for each alternative. Successful completion of the corrective actions would significantly reduce the near-term environmental, safety, and health risks associated with spent fuel storage at INEL.

The INEL has provided support in the development of dry at-reactor storage of special case commercial spent nuclear fuel in accordance with the requirements of the Nuclear Waste Policy Act of 1982 and its 1987 amendments. Dry-storage demonstrations and research at the INEL contributed to the granting of NRC licenses to several utilities for the construction and operation of dry-storage facilities at reactor sites. Research at these facilities is demonstrating the technical feasibility and the economics of adding dry storage capacity in metal or concrete spent fuel storage casks at reactor sites.

3. SPENT NUCLEAR FUEL MANAGEMENT ALTERNATIVES

Chapter 3 describes the alternatives for spent nuclear fuel management as they relate to the Idaho National Engineering Laboratory (INEL) and summarizes and compares potential environmental consequences for each alternative. Chapter 5 contains full descriptions of the consequences of implementing the alternatives.

3.1 Description of Alternatives

DOE has identified five spent nuclear fuel management alternatives:

Alternative 1 - No Action
Alternative 2 - Decentralization (2a, 2b, and 2c)
Alternative 3 - 1992/1993 Planning Basis
Alternative 4 - Regionalization (4a and 4b)
Alternative 5 - Centralization (5a and 5b)

Table 3-1 summarizes the actions that would result from the implementation of these alternatives at the INEL. For each alternative, this table summarizes the proposed transportation, stabilization, storage, research and development, and naval-type fuel examination activities. For alternatives 2, 4, and 5, it identifies a number of options.

The analysis of each alternative considers, as appropriate, existing and projected spent nuclear fuel inventories, existing spent nuclear fuel wet and dry storage facilities, the construction of storage facilities and associated stabilization facilities to achieve interim management objectives, and the relocation of the spent nuclear fuel as appropriate to proposed interim storage facilities.

Table 2-2 lists existing spent nuclear fuel storage facilities with associated type(s) of storage and fuel. Table 3-2 lists the potential facilities and projects required for specific alternatives. DOE has based the potential environmental consequences for each alternative on the existing and proposed facilities and projects listed in Tables 2-2 and 3-2, respectively.

Table 3-1. Summary of spent nuclear fuel management alternatives at the Idaho National Engineering Laboratory. (Page 1)

Table 3-1. (Page 2) Table 3-1. (Page 3) Table 3-2. Potential spent nuclear fuel projects required for each alternative(a).

The alternatives involving the interim storage of naval spent nuclear fuel at sites other than the INEL include a transition period, which would start on June 1, 1995, and continue for approximately 3 years. During this period, approximately 80 shipments of naval spent nuclear fuel would occur to the Expended Core Facility for examination and subsequent shipment to the Idaho Chemical Processing Plant for storage. After this transition period, DOE would phase out the Expended Core Facility such that the worker total at the facility would decline to about 10 by 2001. Appendix D describes this transition period.

3.1.1 Alternative 1: No Action

Table 3-1 lists the basic actions expected under this alternative. This alternative would be restricted to the minimum actions necessary for the continued safe and secure management of spent nuclear fuel. Table 3-3 lists the existing inventory of spent nuclear fuel at the INEL. This alternative is not a status quo condition in terms of spent nuclear fuel receipts (unlike Alternative 3, under which operations would continue in accordance with the 1992/1993 planning basis). Rather, DOE would maintain spent nuclear fuel close to defueling or current storage locations with minimal facility upgrades or replacements.

DOE would continue the operation of the following existing spent nuclear fuel-related facilities: the Fuel Storage Area/Fluorinel Dissolution Process Cell; CPP-603 Underwater Fuel Storage Facility (until 2000); Irradiated Fuel Storage Facility; Underground Storage Facility; Power Burst Facility storage canal; Advanced Test Reactor canal; Advanced Reactivity Measurement Facility; Coupled Fast Reactivity Measurement Facility; Materials Test Reactor canal; Test Area North Pool and Test Pad; Argonne National Laboratory - West Hot Fuel Examination Facility, Radioactive Scrap and Waste Facility, Transient Reactor Test Facility, Zero Power Physics Reactor, and Neutron Radiography Reactor pool. Table 2-2 lists the type(s) of storage and spent nuclear fuels associated with each facility.

3.1.1.1 Transportation. Under this alternative, the INEL would neither receive nor ship spent

nuclear fuel except for naval spent fuel during a transition period. DOE would continue to transfer the Advanced Test Reactor canal spent nuclear fuel to the Idaho Chemical Processing Plant. In addition, DOE could transfer other spent nuclear fuel at the INEL site (e.g., Test Reactor Area, Test Area North Pad, Power Burst Facility storage canal, Experimental Breeder Reactor-II, and Naval Nuclear

Table 3-3. Spent nuclear fuel inventory for each alternative by 2035 (metric tons of heavy metal). ,b,c

Fuel Type	1. No Action(d)	2. Decentralization	3. 1992/1993 Planning Basis	4a. Regionalization by Fuel Type	4b(1)e Regionalization by Geography (INEL)	5a. Centralization at Other DOE Sites	5b. Centralization at the INEL

Naval-type	10.23	N/Cf	+55.00	+55.00	+55.00	-10.23	+55.00
Aluminum-clad	2.91	11.02	+12.09	-2.91	+5.85	-2.91	+210.18
Hanford	None	None	None	None	+2,103.17	None	+2,103.17
Graphite	11.60	N/C	+16.00	+16.01	+16.01	-11.60	+16.01
Special case commercial	122.88	+0.03	+26.69	+33.63	+2.30	-122.88	33.63
Stainless-steel-clad	77.43	+1.08	+1.19	+19.08	+12.69	-77.43	+19.08
Zircaloy-clad	49.09	+0.67	+0.670	+28.90	+15.75	-49.09	+28.90
Other	0.01	+0.82	+0.82	+1.69	+0.28	-0.01	+1.69
Net increase (+)/ decrease (-)	-	+13.62	+112.47	+151.41	+2,211.05	-274.14	+2,467.66
TOTAL	274.14	287.76	386.61	425.55	2,485.19	0	2,741.80

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a. Source: Wichmann (1995).
b. To convert metric tons to tons, multiply by 1.10. Heavy metals are uranium, plutonium, and thorium.
c. The values may not sum exactly due to rounding.
d. The No-Action Alternative represents the present inventory and projections and serves as the basis for determining the net increase or decrease for each type of spent nuclear fuel for each of the other alternatives.
e. Regionalization 4b(2), Regionalization by Geography (Elsewhere), assumes all spent nuclear fuel inventories at the INEL go to the Nevada Test Site or Hanford Site. Inventories for 4b(2) would equal those listed for Alternative 5a.
f. N/C = No change from the No-Action Alternative.

Propulsion Program prototype reactors at the Naval Reactors Facility) to the Idaho Chemical Processing Plant to the extent of its storage capability.

3.1.1.2 Stabilization. Due to the deteriorated condition of some of the fuel in the CPP-603

Underwater Fuel Storage Facility, additional canning and characterization capabilities would be necessary to stabilize this fuel for safe transport and subsequent storage. DOE has scheduled the installation and operation of new fuel canning and characterization equipment in the Irradiated Fuel Storage Facility, which could provide these capabilities, by late 1995. (The installation of such equipment would be a minor upgrade and would have a smaller extent than similar actions described under Alternatives 3, 4, and 5.) DOE could perform other required stabilization of spent nuclear fuel at the INEL in either the Remote Analytical Laboratory or the Fluorinel Dissolution Process Hot Cell.

3.1.1.3 Storage. DOE has identified the CPP-603 Underwater Fuel Storage Facility as one of

five complex-wide spent nuclear fuel storage facilities that exhibit the greatest vulnerabilities according to selected criteria and, therefore, has selected this facility for priority attention (DOE 1993b). As part of the August 9, 1993, agreement between the Secretaries of the Department of Energy and the Department of the Navy and the Governor of Idaho to phase out storage operations in the 45-year old CPP-603 facility, one goal of this and the other alternatives would be to remove spent nuclear fuel from underwater storage in the North and Middle Basins of the CPP-603 facility by the end of 1996 and from the South Basin of this facility by the end of 2000 (DOE 1993a). DOE would relocate this material to the Fuel Storage Area at the Idaho Chemical Processing Plant.

At the Argonne National Laboratory-West, the spent nuclear fuel stored at the Hot Fuel

Examination Facility and the Radioactive Scrap and Waste Facility, primarily Experimental Breeder Reactor-II fuel and blanket elements, would remain in dry storage until its potential processing in the Fuel Cycle Facility. At the Experimental Breeder Reactor-II site, DOE would use dry storage with the exception of the Neutron Radiography Reactor pool fuel. The Test Area North Pool Fuel Transfer project would continue, resulting in the relocation of Test Area North spent pool contents into dry cask storage at the Idaho Chemical Processing Plant by 1998. The dry cask storage required for this project is not related to the Dry Fuels Storage Facility.

DOE would start no new projects to increase spent nuclear fuel storage capacity because there is sufficient storage capacity to meet No-Action storage needs. The planning of spent nuclear fuel storage projects such as the Dry Fuels Storage Facility and Additional Increased Rack Capacity for the Fuel Storage Area would stop.

3.1.1.4 Research and Development. There would be only limited spent nuclear fuel

research and development. Existing spent nuclear fuel management research and development projects would continue. Existing facilities such as the Process Improvement Facility, the Remote Analytical Laboratory, and the Pilot Plant Facility would support continuing research and development work.

3.1.1.5 Naval-Type Fuel Examination. After a transition period, DOE would cease

shipments of naval spent nuclear fuel to the INEL and would phase out the Expended Core Facility. DOE would make onsite shipments of the "library fuel" (a representative sampling of different fuel types maintained for reference purposes) and the spent nuclear fuel that originated at the prototype sites at the Naval Reactors Facility to the Idaho Chemical Processing Plant.

3.1.2 Alternative 2: Decentralization

Under this alternative, DOE could transport fuel for safety or research and development activities. In addition, DOE could undertake actions for safety it deemed desirable, though not essential, and could perform spent nuclear fuel treatment and research and development. As listed in Table 3-3, the anticipated spent nuclear fuel inventory for this alternative would be slightly greater than the inventory for Alternative 1, with the increase consisting primarily of aluminum-clad and stainless-steel-clad spent nuclear fuel from university and foreign research and experimental reactors.

3.1.2.1 Transportation. This alternative assumes that the INEL would accept primarily

limited shipments of spent nuclear fuel from offsite sources into the Fuel Storage Area (e.g., DOE or university reactors) after the Record of Decision for this EIS (1995). Onsite transfers could occur from the Fuel Storage Area to the Storage Facility or the Irradiated Fuel Storage Facility. DOE would consolidate the spent nuclear fuel in the Advanced Test Reactor and in the Materials Test Reactor and Power Burst Facility canals at the Idaho Chemical Processing Plant for canning, characterization, and storage.

As in the No-Action Alternative, there would be a transition period during which the Naval Nuclear Propulsion Program would ship naval spent nuclear fuels to the Expended Core Facility for examination and subsequent shipment to the Idaho Chemical Processing Plant for storage. Section 3.1.2.5 describes the transportation of naval spent fuels that would occur after the transition period.

3.1.2.2 Stabilization. DOE would use the canning and characterization equipment identified in

Section 3.1.1.2 to stabilize spent nuclear fuel removed from the CPP-603 Underwater Fuel Storage Facility for interim underwater storage.

3.1.2.3 Storage. As in Alternative 1, DOE would transfer the spent nuclear fuel in the

CPP-603 Underwater Fuel Storage Facility to the Fuel Storage Area by 2000. DOE would continue to use the Underground Storage Facility and the Irradiated Fuel Storage Facility for existing spent nuclear fuel inventory and transfers of other spent nuclear fuel based on safety analyses. DOE would upgrade or increase fuel storage capacity at the INEL as required.

The Test Area North Pool Fuel Transfer project would result in the relocation of the contents of Test Area North spent nuclear fuel into dry storage at a pad at the Idaho Chemical Processing Plant.

3.1.2.4 Research and Development. The development of technology for the disposition of

spent nuclear fuel would continue. Research and development activities would include laboratory and pilot plant testing, continued repository performance assessments and waste acceptance criteria development, and the characterization of spent nuclear fuel. Shipments of samples or selected spent nuclear fuel assemblies to offsite DOE facilities would be necessary.

3.1.2.5 Naval-Type Fuel Examination. DOE would consider three options for naval reactor

spent nuclear fuel receipt and shipment. Under options 2a and 2b, DOE would stop shipments of naval spent nuclear fuel to the INEL and would shut down the Expended Core Facility. Option 2c would enable the continued receipt of naval-type fuel for examination at the Expended Core Facility and its return to the originating shipyards for storage in transport casks. Chapter 3 of Appendix D further describes these options. As with Alternative 1, each option would require approximately a 3-year transition period. During this period, DOE would transport spent nuclear fuel in shipping containers to the Expended Core Facility, unload the containers, and use them to support additional refuelings and defueling.

3.1.3 Alternative 3: 1992/1993 Planning Basis

This alternative is consistent with DOE plans at the INEL before the injunction that stopped spent nuclear fuel shipment to the INEL; it assumes a 40-year planning horizon for the continued transportation, receipt, stabilization, and storage of spent nuclear fuel. As with Alternative 1, DOE would continue the maintenance and operation of existing spent nuclear fuel-related facilities; however, some consolidation of INEL facilities could occur. DOE would send newly generated spent nuclear fuel to either the INEL or the Savannah River Site. DOE would assess the construction of new facilities to accommodate current and projected spent nuclear fuel management requirements.

The amount of spent nuclear fuel at the INEL under this alternative would be greater than that for either Alternative 1 or 2 (see Table 3-3) because this alternative assumes that the INEL would manage, before stabilization and disposal, its present inventory (see Alternative 1) plus additional receipts of DOE spent nuclear fuel, including the following:

- Naval-type spent nuclear fuel
- Approximately half of the aluminum-clad spent nuclear fuel from university and foreign research and experimental reactors
- All Training Reactor Isotopics General Atomics (TRIGA) spent nuclear fuels from the

Hanford Site and approximately half of that from foreign, DOE, and university reactors

- Fort St. Vrain spent nuclear fuel from Public Service of Colorado
- Special case commercial pressurized water reactor and boiling water reactor spent nuclear fuel from the DOE facility in West Valley, New York
- Miscellaneous spent nuclear fuel types from such DOE sites as Los Alamos, New Mexico, and Oak Ridge, Tennessee, and from university reactors and other locations

3.1.3.1 Transportation. DOE would consolidate the spent nuclear fuel in the Test Reactor

Area (Advanced Test Reactor canal, Materials Test Reactor canal, and Coupled Fast Reactivity Measurements Facility and Advanced Reactivity Measurement Facility canal) and the Power Burst Facility at the Idaho Chemical Processing Plant for canning and dry storage.

The INEL would receive and temporarily store new spent nuclear fuels in the Fuel Storage Area. Transfers could occur from the Fuel Storage Area to the Underground Storage Facility or the Irradiated Fuel Storage Facility or, when available, the dry storage vaults at the proposed Dry Fuels Storage Facility.

At present, DOE is transferring spent nuclear fuel from the Advanced Test Reactor Canal to the Idaho Chemical Processing Plant. DOE would maintain this canal for the storage and management of its recyclable fuel assemblies until the reactor no longer had a mission. The Experimental Breeder Reactor-II spent nuclear fuel in storage would remain at Argonne National Laboratory-West. As with Alternative 2, the Test Area North Pool Fuel Transfer project would result in the relocation of the contents of the Test Area North spent nuclear fuel pool to dry storage at a pad at the Idaho Chemical Processing Plant.

3.1.3.2 Stabilization. DOE would complete a new Canning and Characterization Facility with

appropriate inspection, stabilization, and packaging equipment to stabilize new receipts of spent nuclear fuel and to prepare fuel currently in underwater storage for dry storage. This facility would be an integral part of the Dry Fuels Storage Facility that DOE would complete under this alternative. Until the Dry Fuels Storage Facility is in service, DOE would use the canning and characterization equipment described under Alternative 1 to stabilize spent nuclear fuel removed from the CPP-603 Underwater Fuel Storage Facility for interim underwater storage.

3.1.3.3 Storage. As with Alternative 2, DOE would upgrade or increase dry fuel storage

capacity at the INEL as required. DOE would complete the Fuel Storage Area increased Rack Capacity project in 1997. Coupled with stringent fuel management and, if necessary, temporary storage of some aluminum fuel in stainless steel racks, this project would allow the Fuel Storage Area to accept all of the project spent nuclear fuel receipts until the Additional Increased Rack Capacity project would be completed in 2001. The Additional Increased Rack Capacity project would allow the Fuel Storage Area to accept the projected spent nuclear fuel receipts until the Dry Fuels Storage Facility project would become available in 2005. The INEL would receive the Fort St. Vrain spent nuclear fuel in the Irradiated Fuel Storage Facility on a space-available basis or in the new vault storage in the Dry Fuels Storage Facility. Modifications to the Irradiated Fuel Storage Facility cask handling equipment would be necessary to accept the new Fort St. Vrain shipping casks.

DOE would continue to use the Underground Storage Facility and the Irradiated Fuel Storage Facility for current inventory and for transfers of other fuel inventories based on safety analyses. Based on these safety analyses, upgrades would be limited to those required for facility safety improvements and for making transfers safely.

3.1.3.4 Research and Development. Spent nuclear fuel research and development would

continue as planned, with the construction of a Technology Development Facility. The Electrometallurgical Process Demonstration Project at Argonne National Laboratory - West Fuel Cycle Facility would continue. In addition, Argonne National Laboratory would implement the EBR-II Blanket Processing project under this alternative. The Dry Fuels Storage Facility would develop and demonstrate technology for the dry storage of selected DOE highly enriched uranium fuels.

3.1.3.5 Naval-Type Fuel Examination. The practice of transporting spent nuclear fuel from

naval reactors to the Expended Core Facility at the INEL would resume. After an examination, DOE would transfer such fuel to the Idaho Chemical Processing Plant for interim storage pending final disposition. Under this alternative, the Naval Nuclear Propulsion Program would complete the Expended Core Facility Dry Cell Construction project.

3.1.4 Alternative 4: Regionalization

This alternative assumes that DOE would base the spent nuclear fuels shipped between DOE sites and the receipt of fuels from other locations primarily on either geography or fuel type. Alternative 4 offers two options for the redistribution of existing and new spent nuclear fuel:

- Option 4a assumes that DOE would base the spent nuclear fuels shipped between DOE sites and the receipt of fuels from other locations at the INEL, Hanford Site, or the Savannah River Site primarily on fuel type.

- Option 4b assumes that DOE would base the spent nuclear fuels shipped between DOE sites and the receipt of fuels on geography. There would be a single western site at either the Hanford Site, INEL or Nevada Test Site. Option 4b(1) in which the INEL is the western regional site is essentially the same as Alternative 5b. Option 4b(2) in which INEL ships all SNF to another western regional site is the same as Alternative 5a.

3.1.4.1 Transportation. Under option 4a, the INEL would receive all Zircaloy- and

stainless-steel-clad spent nuclear fuel. This redistribution would optimize DOE spent nuclear fuel management.

The spent nuclear fuel inventory involved under option 4a would be greater than those for Alternative 1, 2, or 3 because this alternative assumes that the INEL would manage its present inventory plus the following additional spent nuclear fuels (see Table 3-3) prior to stabilization and disposal:

- Naval-type spent nuclear fuel

- All spent nuclear fuel except aluminum-clad fuel and Hanford spent nuclear fuel

- All Training Reactor Isotopics General Atomics spent nuclear fuels from the Hanford Site

- Fort St. Vrain spent nuclear fuel from Public Service of Colorado

- Special case commercial pressurized water reactor and boiling water reactor spent nuclear fuel from the DOE facility in West Valley, New York

Under option 4b(1), DOE would regionalize all western DOE SNF at the INEL. DOE would transport all spent nuclear fuel at other western sites to the INEL. Because the fuel inventory for this alternative would be within 15 percent of that for Alternative 5b, analyses for this option conservatively assume that environmental impacts would be the same as those for as Alternative 5b - Centralization at INEL.

Under option 4b(2), DOE would regionalize all western DOE SNF at either the Nevada Test Site or Hanford Site. DOE would transport spent nuclear fuel at the INEL to the selected western site. As such, this option would be the same as Alternative 5a - Centralization at Other DOE Sites.

3.1.4.2 Stabilization. DOE would stabilize the spent nuclear fuels it would retain at the INEL

as planned for Alternative 3, with the construction of such new facilities as a canning and characterization facility and the Dry Fuels Storage Facility. Options 4a and 4b(1) would require such a facility for the receipt and storage of spent nuclear fuel, while option 4b(2) would require stabilization capabilities for shipping spent nuclear fuel. For spent nuclear fuel that the INEL would ship to other regional sites, the receiving site would perform any stabilization beyond that required for transportation.

3.1.4.3 Storage. Under option 4a, DOE would increase dry storage capacity and undertake

facility upgrades similar to those described for Alternative 3, with replacements and additions as appropriate. Under option 4b(1), DOE would increase dry storage capacity and undertake facility upgrades similar to those described for Alternative 5b, with replacements and additions as appropriate.
Option 4b(2) would not require increased storage capacity and, therefore, there would be no facility upgrades.

3.1.4.4 Research and Development. As with Alternative 3, this alternative would include

the continuation of activities related to the treatment of spent nuclear fuel, including research and development (e.g., Electrometallurgical Process Demonstration Project), and the construction of the Dry Fuels Storage Facility. DOE would initiate pilot programs as needed to support future decisions on spent nuclear fuel management and disposition. DOE would use historic data on spent nuclear fuel to provide the bounding case for a determination of the impacts associated with potential pilot program activities.

3.1.4.5 Naval-Type Fuel Examination. Under options 4a and 4b(1), the transportation of

spent nuclear fuel from naval reactors to the Expended Core Facility at the INEL would resume. As with Alternative 1, under option 4b(2) DOE would phase out shipments of naval-type spent nuclear fuel to the INEL and would phase out the Expended Core Facility.

3.1.5 Alternative 5: Centralization

Under this alternative, DOE would send all current and future spent nuclear fuel inventories from both DOE and the Naval Nuclear Propulsion Program to one DOE site for interim storage until final disposition.

The two options under Alternative 5 encompass the extreme ranges of spent nuclear fuel inventories that DOE could store at the INEL (i.e., all or none of the inventory). Under option 5a, DOE would ship the INEL spent nuclear fuel inventory off the site to the Hanford Site, the Savannah River Site, the Nevada Test Site, or the Oak Ridge Reservation. Under option 5b, DOE would ship all existing spent nuclear fuel to the INEL.

This alternative would bound the maximum number of spent nuclear fuel-related actions that DOE could reasonably undertake at any site. DOE would have to build new facilities at the selected site to accommodate the increased inventories. Shipments of spent nuclear fuel to the sites not selected as the centralized destination would continue as an interim action pending the construction of necessary storage and examination facilities at the selected site. DOE would then transfer all spent nuclear fuel to the selected site, and the other sites would close their spent nuclear fuel facilities. Before DOE would ship spent nuclear fuel from the originating site, it would characterize and can all spent nuclear fuel as necessary.

The locations from which spent nuclear fuel would originate, in addition to the Hanford Site and Savannah River Site, would include Argonne National Laboratory - East, Babcock and Wilcox, Brookhaven National Laboratory, General Atomics, Los Alamos National Laboratory, Oak Ridge National Laboratory, Sandia National Laboratories, West Valley, and Fort St. Vrain. This alternative would also include fuel that might be returned to the United States following irradiation or testing.

This alternative would include activities related to the treatment of spent nuclear fuel, including research and development and pilot programs to support future decisions on its disposition. DOE would use historic data on spent nuclear fuel to provide a foundation case for determining the impacts associated with potential pilot program activities.

3.1.5.1 Alternative 5a - Centralization at Other DOE Sites.

3.1.5.1.1 Transportation - This option assumes that the INEL would consolidate and

prepare all existing and projected onsite spent nuclear fuel for shipment to another DOE facility: the Hanford Site, the Savannah River Site, the Nevada Test Site, or Oak Ridge.

3.1.5.1.2 Stabilization - The DOE would construct a canning and characterization facility

at the Idaho Chemical Processing Plant to accept the different types of INEL spent nuclear fuel in various shipping casks and storage containers, and to stabilize these fuel types before their shipment to the selected DOE facility.

3.1.5.1.3 Storage - As in Alternative 1, DOE would complete the CPP-603 Underwater

Fuel Storage Facility pool inventory transfer to existing dry storage facilities by 2000. DOE would not build the Dry Fuels Storage Facility. DOE would then close all spent nuclear fuel-related facilities at the INEL with the exception of those in direct support of operating reactors, such as the Advanced Test Reactor canal or the Argonne National Laboratory-West Hot Fuel Examination Facility and Fuel Cycle Facility. This closure would require the establishment of a major surveillance and maintenance operation until DOE determined the disposition of these facilities. The timeframe for closure would depend on the following factors:

- The time necessary to stabilize the spent nuclear fuel in the CPP-603 Underwater Fuel Storage Facility
- The time necessary for the selected DOE site to prepare facilities qualified to accept the spent nuclear fuel
- The time necessary for the procurement and licensing of shipping containers that would be compatible with the selected receiving DOE site

The spent nuclear fuel inventory that DOE would export off the INEL site for Alternative 5a is the same quantity listed for Alternative 1 (see Table 3-3).

3.1.5.1.4 Research and Development - Under this option there would be a phaseout of

all research and development activities, although the Electrometallurgical Process Demonstration Project would continue at the Argonne National Laboratory - West Fuel Cycle Facility (but would stabilize only spent nuclear fuel currently on the site).

3.1.5.1.5 Naval-Type Fuel Examination - As with Alternative 1, DOE would phase out

shipments of naval-type spent nuclear fuel to the INEL and would phase out the Expended Core Facility.

3.1.5.2 Alternative 5b - Centralization at the INEL.

3.1.5.2.1 Transportation - This option assumes that the INEL would receive all DOE and

naval-type spent nuclear fuel (see Table 3-3).

3.1.5.2.2 Stabilization - The Hanford Site, the Savannah River Site, and other DOE

facilities would stabilize as necessary, spent nuclear fuel for safe transportation to the Idaho Chemical Processing Plant. The Hanford Site, the Savannah River Site, and other DOE facilities would procure an undetermined number of additional casks and install cask handling equipment as necessary. DOE would complete an expanded Dry Fuels Storage Facility at the INEL, which would include a new Canning and Characterization Facility similar to that described for Alternative 3. This facility would, if needed, repackage the spent nuclear fuel into compatible canisters for dry storage. Other new facility projects would be the same as those described for Alternative 3. In addition, DOE would begin stabilizing for safe storage all complex-wide spent nuclear fuel, as necessary, in existing facilities at the Idaho Chemical Processing Plant. Upgrades and new facilities would be necessary to support long-term fuel stabilization for ultimate disposition; this would address criticality (unplanned and uncontrolled nuclear fission) concerns about the disposal of spent nuclear fuel in a potential Federal repository.

3.1.5.2.3 Storage - Projects and activities for storage of spent nuclear fuel would be similar

to those described for Alternative 3, except that accelerated schedules for the Increased Rack Capacity and Additional Increased Rack Capacity projects would be necessary to accommodate the increased fuel receipts. In addition, the schedule for the Dry Fuel Storage Facility project would have to be accelerated and its scope expanded. For example, the Increased Rack Capacity project may have to be completed in late 1996, the Additional Increased Rack Capacity project may have to be completed in late 1998, and the Expanded Dry Fuels Storage Facility project may have to be completed in 2002. If the Expanded Dry Fuels Storage Facility would become available even earlier, it could eliminate the need for the Additional Increased Rack Capacity project.

3.1.5.2.4 Research and Development - DOE would conduct maximum spent nuclear

fuel research and development under this option.

As with Alternative 4, the Electrometallurgical Process Demonstration Project would continue at the Argonne National Laboratory - West.

3.1.5.2.5 Naval-Type Fuel Examination - Similar to Alternative 3, the practice of

transporting spent nuclear fuel from naval reactors to the Expended Core Facility at the INEL would resume.

3.2 Comparison of Alternatives

Chapter 5 analyzes the environmental consequences of the alternatives. Tables 3-4 through 3-6 summarize and compare the potential impacts associated with each alternative from the information in Chapter 5 for construction, normal operations, and accidents, respectively.

A review of the impacts of the alternatives, as presented in Chapter 5, indicates that impacts would be minimal or negligible in most areas. Further, most areas with measurable impacts would have no appreciable differences among alternatives.

In general, the levels of potential impacts associated with Alternatives 1 through 4 (option 4a) would be similar because the amounts of spent nuclear fuel that DOE would manage at the INEL under these alternatives would be on the same order of magnitude (e.g., 300 to 450 MTHM) and activities would extend throughout the full 40-year management period. The lowest level of overall potential impact at the INEL would occur under Alternative 4b(2) - Regionalization by Geography (Elsewhere) and Alternative 5a - Centralization at Other DOE Sites because DOE would ship INEL spent nuclear fuel off the site well before the management period ended in 2035. Alternative 5b and Alternative 4b(1), under which DOE would ship all or nearly all spent nuclear fuel to the INEL, would result in the greatest potential onsite impacts.

4. AFFECTED ENVIRONMENT

4.1 Overview

Chapter 4 describes the existing environment at the Idaho National Engineering Laboratory (INEL) site and the surrounding region. It emphasizes areas that the proposed spent nuclear fuel management alternatives could affect. The information in this chapter provides the existing environmental conditions against which the Department of Energy (DOE) can measure the potential environmental effects of the alternatives. It supports the assessment of the potential environmental consequences that Chapter 5 discusses. DOE used the discussion of the Affected Environment in Volume 2 of this EIS as input for this chapter.

4.2 Land Use

The INEL site encompasses 570,914 acres (2,310.4 square kilometers) in Butte, Bingham, Jefferson, Bonneville, and Clark Counties, Idaho. This section describes existing land uses at the INEL and in the surrounding region, and land use plans and policies applicable to the surrounding area.

4.2.1 Existing and Planned Land Uses at the INEL

Categories of land use at the INEL include facility operations, grazing, general open space, and infrastructure such as roads. Facility operations include industrial and support operations associated with energy research and waste management activities (DOE also conducts such activities at its Idaho Falls facilities). In addition, DOE uses INEL land for recreation and environmental research associated with the designation of the INEL as a National Environmental Research Park.

Much of the INEL is open space that DOE has not designated for specific uses. Some of this open space serves as a buffer zone between INEL facilities and other land uses. Facilities and operations use about 2 percent of the total INEL site area (11,400 acres or 46 square kilometers). Public access to most facility areas is restricted. Approximately 6 percent of the INEL, or 32,985 acres (133.5 square kilometers), is devoted to public roads and utility rights-of-way that cross the site. Recreational uses include public tours of general facility areas and the Experimental Breeder Reactor-I (a National Historic Landmark), and controlled hunting, which is generally restricted to 0.5 mile (0.8 kilometer) inside the INEL boundary.

Cattle and sheep grazing occupies between 300,000 and 350,000 acres (1,200 and 1,400 square kilometers). The U.S. Sheep Experiment Station uses a 900-acre (3.6-square-kilometer) portion of this land, at the junction of Idaho State Highways 28 and 33, for a winter feed lot for approximately 6,500 sheep. Grazing is not allowed within 2 miles (3.2 kilometers) of any nuclear facility and, to avoid the possibility of milk contamination by long-lived radionuclides, dairy cattle are not permitted on the site. The Department of the Interior's Bureau of Land Management grants and administers rights-of-way and grazing permits. Figure 4.2-1 shows selected land uses at the INEL and in the surrounding region.

Figure 4.2-1 Selected land uses at the INEL and in the surrounding region.

The INEL site is within the Medicine Lodge Resource Area (approximately 140,415 acres or 568.3 square kilometers in the eastern and southern portions of the INEL site) and the Big Butte Resource Area (430,499 acres or 1,742 square kilometers in the central and western portions); the Bureau of Land Management administers both of these areas. Under Resource Management Plans, the Bureau manages portions of these Resource Areas for grazing and wildlife habitat. No mineral exploration or development is allowed on INEL land.

DOE land use plans and policies applicable to the INEL include the INEL Institutional Plan - Fiscal Year 1994 - 1999 (DOE-ID 1993c) and the INEL Technical Site Information Report (DOE-ID 1993a). The Institutional Plan provides a general overview of INEL facilities, outlines strategic program directions and major construction projects, and identifies specific technical programs and capital equipment needs. The Technical Site Information Report presents a 20-year master plan for development activities at the site. Under the scope of these planning documents, energy research and waste management activities would continue in existing facility areas and, in some instances, expand into currently undeveloped site areas. These documents also describe environmental restoration, waste management, and spent nuclear fuel activities. Projected land use scenarios for the next 25 to 50 years include the outgrowth of current functional areas and the possible development of waterfowl production ponds in existing grazing areas.

No onsite land use restrictions due to Native American treaty rights would exist for any of the alternatives described in this EIS. The INEL does not lie within any of the land boundaries established by the Fort Bridger Treaty, and the entire INEL site is land occupied by the U.S. Department of Energy. Therefore, the provisions in the Fort Bridger Treaty that allows the Shoshone-Bannock Indians to hunt on unoccupied lands of the United States do not apply to the INEL site.

4.2.2 Existing and Planned Land Use in Surrounding Areas

The Federal government, the State of Idaho, and private parties own the lands surrounding the INEL site. Land uses on Federally owned land consist of grazing, wildlife management, range land, mineral and energy production, and recreational uses. State-owned lands are used for grazing, wildlife management, and recreational purposes. Privately owned lands are used primarily for grazing, crop production, and range land.

Small communities and towns near the INEL boundaries include Mud Lake to the east; Arco, Butte City, and Howe to the west; and Atomic City to the south. The larger communities of Idaho Falls, Rexburg, Blackfoot, and Pocatello and Chubbock are to the east and southeast of the INEL site. The Fort Hall Indian Reservation is to the southeast of the INEL. Recreation and tourist attractions in the region around the INEL include the Craters of the Moon National Monument, Hell's Half Acre Wilderness Study Area, Black Canyon Wilderness Study Area, Camas National Wildlife Refuge, Market Lake State Wildlife Management Area, North Lake State Wildlife Management Area, Yellowstone National Park, Grand Teton National Park, Jackson Hole Recreation Complex, Targhee and Challis National Forests, and the Snake River.

Lands surrounding the INEL site are subject to Federal and state planning laws and regulations. Federal rules and regulations that require public involvement in their implementation govern planning for and use of Federal lands and their resources. Land use planning in the State of Idaho is derived from the Local Planning Act of 1975 (State of Idaho Code 1975). Because the State currently has no land use planning agency, the Idaho legislature requires each county to adopt its own land use planning and zoning guidelines. County plans that are applicable to lands bordering the INEL site include the Clark County Planning and Zoning Ordinance and Interim Land Use Plan (Clark County 1994); Bonneville County Comprehensive Plan (Bonneville County 1976); Bingham County Zoning Ordinance and Planning Handbook (Bingham County 1986); Jefferson County Comprehensive Plan (Jefferson County 1988); and Butte County Comprehensive Plan (Butte County 1992). Land use planning for INEL facilities within the Idaho Falls city limits is subject to Idaho Falls planning and zoning restrictions (City of Idaho Falls 1989, 1992).

All county plans and policies accept development adjacent to previously developed areas to minimize the need to extend infrastructure improvements and to avoid urban sprawl. Because the INEL is remote from most developed areas, INEL lands and adjacent areas are not likely to experience residential and commercial development; no new development is planned near the INEL site. However, DOE expects recreational and agricultural uses to increase in the surrounding area in response to greater demand for recreational areas and the conversion of range land to crop land.

4.3 Socioeconomics

This section presents a brief overview of current socioeconomic conditions within a region of influence where approximately 97 percent of the INEL workforce lived in 1991 (DOE-ID 1991). The INEL region of influence is a seven-county area comprised of Bingham, Bonneville, Butte, Clark, Jefferson, Bannock, and Madison Counties. The region of influence also includes the Fort Hall Indian Reservation and Trust Lands (home of the Shoshone-Bannock Tribes) in Bannock, Bingham, Caribou, and Power Counties.

4.3.1 Employment

Historically, the regional economy has relied predominantly on natural resource use and extraction. Today, farming, ranching, and mining remain important components of the regional economy. Idaho Falls is the retail and service center for the region of influence, and Pocatello has evolved into an important processing and distribution center and site of higher education institutions.

4.3.1.1 Region. The labor force in the region of influence increased from 92,159 in 1980 to

104,654 in 1991, an average annual growth rate of approximately 1.2 percent. In 1991 the region of influence accounted for approximately 18 percent of the total state labor force of 504,000 (ISDE 1992). As listed in Table 4.3-1, the projected labor force in the region of influence will reach 108,667 by 1995.

Unemployment rates varied considerably among the counties of the region of influence in 1991, ranging from 2.6 percent in Clark County to 6.3 percent in Bannock and Bingham Counties. Since 1980 the average annual unemployment rate for the region has ranged from 5.3 percent in 1989 to 8.3 percent in 1983. In 1991 the average annual unemployment rate for the region of influence was 5.5 percent compared to the statewide average of 6.2 percent (ISDE 1992).

Employment in the region of influence increased from 86,261 in 1980 to 98,898 in 1991, an average annual growth rate of approximately 1.3 percent. As listed in Table 4.3-1, employment is projected to increase to 101,450 by 1995.

Table 4.3-1. Projected labor force, employment, and population for the INEL region of influence, 1995-2004.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Labor Force	108,667	109,607	110,547	111,487	112,427	113,367	114,308	115,248	116,188	117,128
Employment	101,450	102,328	103,205	104,083	104,960	105,838	106,716	107,593	108,471	109,348
Population	247,990	251,518	255,096	258,726	262,406	266,140	268,667	271,219	273,795	276,395

Source: ISDE (1992); SAIC (1994); ISDE (1991); ISDE (1986).

4.3.1.2 Idaho National Engineering Laboratory. INEL plays a substantial role in the

regional economy. During Fiscal Year 1990, INEL directly employed approximately 11,100 personnel, accounting for almost 12 percent of total regional employment. The estimated population directly supported by INEL employment was approximately 38,000 persons, or 17 percent of the total regional population. The major employers at INEL are DOE-ID, DOE-ID contractors, Argonne National Laboratory-West, and the Naval Reactors Facility (see Figure 4.3-1). In 1992, the total direct INEL employment was approximately 11,600 jobs (DOE-ID 1994). Projections as of January 1995 indicate that the total number of jobs at INEL will decrease to approximately 8,620 in Fiscal Year 1995 and to approximately 7,250 in Fiscal Year 2004 (Tellez 1995). Projected decreases in INEL employment are primarily related to contractor consolidation, which accounts for 64 percent of the projected losses between Fiscal Year 1994 and Fiscal Year 2004, and to reduced activities at the Naval Reactors Facility, which accounts for 33 percent of the projected job losses. Contract changes at DOE-ID resulted in the consolidation of several contracts under one contract. The consolidation eliminated redundant administrative activities previously performed by each individual contractor and offered early retirement or other options to impacted INEL contractor employees.

4.3.2 Population and Housing

4.3.2.1 Population. From 1960 to 1990, population growth in the region of influence

mirrored statewide growth. During this period, the region's population increased at an average annual rate of approximately 1.3 percent, while the growth rate for the State was 1.4 percent. Between 1980 and 1990, population growth in the region of influence approximately equaled that of the State with an average growth rate of 0.6 percent per year. The region of influence had a 1990 population of 219,713, which comprised 22 percent of the total State population of 1,006,749. Based on population and employment trends, the population in the region of influence will reach approximately 248,000 persons by 1995 (Table 4.3-1).

Figure 4.3-1. Historic and projected employment at the Idaho National Engineering Laboratory, 1990- 2004.

In 1990, the most populous counties were Bannock and Bonneville, which together contained over 60 percent of the seven-county total (Figure 4.3-2). Butte and Clark were the least populous of the counties in the region of influence. The largest cities in the region of influence are Pocatello and Idaho Falls, with 1990 populations of approximately 46,000 and 44,000, respectively. In 1990, the Fort Hall Indian Reservation and Trust Lands contained 5,113 residents, most of whom (52 percent) resided in Bingham County.

4.3.2.2 Housing. Bonneville and Bannock Counties (which respectively include the cities of Idaho Falls and Pocatello) provided 67 percent of the 73,230 year-round housing units in the region of influence in 1990 (see Table 4.3-2). Of this number, approximately 70 percent were single-family units, 17 percent were multifamily units, and 13 percent were mobile homes. Most of the multifamily units (75 percent) were in Bonneville and Bannock Counties. About 29 percent of the occupied housing units in the region were rental units and 71 percent were homeowner units (USBC 1992).

The median value of owner-occupied housing units ranged from $37,300 in Clark County to $68,700 in Madison County, and median monthly rents ranged from $243 in Butte County to $366 in Bonneville County. In 1990, there were 1,510 occupied housing units on the Fort Hall Indian Reservation and Trust Lands (USBC 1992) and a vacancy rate of 14 percent.

4.3.3 Community Services

This assessment considers the following selected community services in the region of influence: public schools, law enforcement, fire protection, hospital services, and solid waste disposal. Table 4.3-3 summarizes pertinent characteristics of these services for the region of influence.

Seventeen public school districts and three nonpublic schools provide educational services for **about 58,000 children in the region of influence.** Of these students, about 6,500 were dependents of INEL-related employees. During the 1990-1991 academic year, most public school districts spent an average of $3,000 to $4,000 per student annually. Higher education in the region is provided by the University of Idaho, Idaho State University, Brigham Young University, Ricks College, and the Eastern Idaho Technical College.

Seven county sheriff's offices, 12 city police departments, and the Idaho State Police provide law enforcement services in the region. There was a total of 479 sworn officers and 100 other law enforcement personnel in 1991, more than 59 percent of whom served Bannock and Bonneville Counties.

Figure 4.3-2. Historic and projected total population for the counties of the region of influence, 1940 through 2004.

Table 4.3-2. Number of housing units, vacancy rates, median house value, and median monthly rent by county and region of influence.

County	Homeowner housing units Number of units	Vacancy rates	Median value ($)	Rental units Number of units	Vacancy rates	Median monthly rent ($)
Bannock	16,447	2.4	53,300	7,467	10.3	294
Bingham	9,010	2.0	50,700	2,955	9.2	284
Bonneville	17,707	1.9	63,700	7,375	6.2	366
Butte	780	4.6	41,400	302	16.2	243
Clark	177	1.7	37,300	114	9.6	281
Jefferson	4,000	2.0	54,300	992	4.1	314
Madison	3,522	1.3	68,700	2,392	2.8	299
Region of influence	51,674	2.1	-	21,556	4.6	-

a. Source: USBC (1992).

Eighteen fire districts in the region of influence operate 30 fire stations staffed by 180 paid and approximately 300 volunteer firefighters. Bingham, Bonneville, Butte, Clark, and Jefferson Counties, which surround the INEL, have developed emergency plans to be implemented in the event of a radiological or hazardous materials emergency. Each emergency plan identifies facilities with extremely hazardous substances and defines transportation routes for these substances. The emergency plans also include procedures for notification and response, listings of emergency equipment and facilities, evacuation routes, and training programs.

Eight hospitals serve the region of influence with more than 900 licensed beds and a capacity of nearly 128,000 patient-days per year. Occupancy rates range from 22.0 to 61.7 percent in the region (IDHW 1990). County governments and the Blackfoot, Dubois, Idaho Falls, and Pocatello fire departments provide regional ambulance services. A private ambulance company serves residents in Butte County. Four quick-response units, two medical helicopters, and two clinics specializing in emergency medical services also serve the region of influence (Hardinger 1990; U.S. West Directories 1992).

Table 4.3-3. Summary of public services available in the region of influence.

Public Service	County Bannock	Bingham	Bonneville	Butte	Clark	Jefferson	Madison
Schools							
Number of public school districts	2	5	3	1	1	3	2
Total enrollment	15,455	11,311	17,896	765	166	5,339	5,967
Number of INEL-related students (excluding military)	485	1,532	4,040	301	5	134	47
Health Care Delivery							
Number of hospitals	3	2	1	1	0	0	1
Number of licensed beds	309	238	311	4	-	-	52
Law Enforcement							
Number of sworn law enforcement officers	151	65	143	4	2	18	43
Total personnel per 1000 population	2.5	2.0	2.2	1.3	6.3	1.6	1.9
Fire Protection							
Number of fire stations	9	7	6	2	1	4	1
Number of firefighters	166	96	121	15	7	63	24
Number of firefighting vehicles	37	25	24	3	1	11	6
Municipal Solid Waste Disposal							
Number of landfills meeting EPA[b] regulations	1[c]	3[d]	1[e]	2	0[f]	1	0[f]
Expected lifespan in years	30	3-6	50	30	-	2	-

a. Source: IDE (1991); IDHW (1990); IDLE (1991); Kouris (1992a); and Kouris (1992b).
b. EPA = U.S. Environmental Protection Agency.
c. Fort Hall Mine Landfill is being redesigned to meet EPA standards.
d. Aberdeen Landfill may close due to noncompliance with EPA standards.
e. A new landfill is replacing Bonneville County Landfill.
f. Madison and Clark Counties are evaluating a regional landfill for use after 1993.

Municipal solid waste generated in the region of influence is transported to county landfills. In 1992, twelve landfills served the region of influence. Four landfills (one each in Bannock, Clark, Jefferson, and Madison Counties) will close without replacement before reaching their planned capacity due to noncompliance with new Environmental Protection Agency standards (CFR 1991a).

4.3.4 Public Finance

In Fiscal Year 1991, total county revenues for the region of influence amounted to approximately $90 million (see Table 4.3-4). County governments receive most of their revenues from taxes and intergovernmental transfers. In 1991 the total assessed value of taxable property in the region of influence was about $4.5 billion. In addition to property tax revenues, local governments (cities and counties) also receive revenue from sales tax disbursements and revenue-sharing programs. These two sources provide approximately 60 to 85 percent of the total revenues received by each county.

Table 4.3-4. Total revenues and expenditures by county, Fiscal Year 1991.

County	Total revenues ($)	Total expenditures ($)
Bannock	16,232,274	14,216,708
Bingham	11,434,200	10,708,011
Bonneville[b]	50,186,650	51,850,100
Butte	1,417,684	1,397,012

Clark	1,236,849	1,086,379
Jefferson	4,408,236	4,566,074
Madison	5,249,432	5,662,080
Seven-county region	90,165,325	89,486,364

a. Sources: Ghan (1992); Bingham County (circa 1992); McFadden (circa 1992); Swager & Swager (1992a); Swager & Swager (1992b); Draney, Searle, and Associates (1992); Schwendiman & Sutton (1992).

b. Bonneville County's financial statements and total revenue data include special accounts for schools, cities, cemeteries, fire districts, ambulance districts, and other special accounts not found in other county budgets. The majority of intergovernmental revenue is used to fund these accounts.

Although DOE as a Federal agency is exempt from paying state or local taxes, INEL employees and contractors are not. In 1992, INEL employees paid an estimated $60 million in Federal withholding tax and $24 million in state withholding tax.

In 1991 the major categories of county government expenditures were general government services, 27 percent; road maintenance, 18 percent; public safety, 16 percent; health and welfare programs, 16 percent; sanitation and public works, 9 percent; debt service, 3 percent; trust remittances, 2 percent; and other expenditures, 9 percent.

4.4 Cultural Resources

This section discusses cultural resources at the INEL, including prehistoric and historic archeological sites and historic sites and structures, and traditional resources that are of cultural or religious importance to local Native Americans. It also discusses paleontological localities on the INEL site.

4.4.1 Archeological Sites and Historic Structures

As summarized in the INEL Draft Management Plan for Cultural Resources (Miller 1992), the INEL contains a rich and varied inventory of cultural resources. This includes fossil localities that provide an important paleontological context for the region and the many prehistoric archeological sites that are preserved within it. These latter sites, including campsites, lithic workshops, cairns, and hunting blinds, among others, are also an important part of the INEL inventory because they provide information about the activities of aboriginal hunting and gathering groups who inhabited the area for approximately 12,000 years. In addition, archeological sites, pictographs, caves, and many other features of the INEL landscape are also important to contemporary Native American groups for historic, religious, and traditional reasons. Historic sites, including the abandoned town of Powell/Pioneer, a northern spur of the Oregon Trail known as Goodale's Cutoff, many small homesteads, irrigation canals, sheep and cattle camps, and stage and wagon trails, document the use of the area during the late 1800s and early 1900s. Finally, the many scientific and technical facilities inside the INEL boundaries have preserved important information on the historic development of nuclear science in America.

To date, more than 100 cultural resource surveys have been conducted over approximately 4 percent of the area on the INEL site. These surveys, most of which have occurred near major facility areas, have identified 1,506 archeological resources, including 688 prehistoric sites, 38 historic sites, 753 prehistoric isolates, and 27 historic isolates (Miller 1992; Gilbert and Ringe 1993). These numbers do not include architectural properties associated with the creation and operation of the INEL. Until formal significance evaluations (archeological testing and historic records searches) have been completed, all cultural sites in this inventory are considered to be potentially eligible for nomination to the National Register of Historic Places. However, all the isolates have been categorized as unlikely to meet eligibility requirements (Yohe 1993).

Due to the relatively high density of prehistoric sites on the INEL and the need to consider these resources during Federal undertakings, DOE has sponsored a preliminary study, which resulted in the development of a predictive model, to identify areas where densities of sites are highest and where the potential impacts to significant archeological resources, as well as costs of compliance, would increase correspondingly (Ringe 1993). This information provides guidance for INEL project managers in the selection of appropriate areas for new construction. However, it does not take the place of inventories that are required by the National Historic Preservation Act before ground-disturbing projects can start (NHPA 1966 as amended).

The predictive model, constructed using a multivariate statistical technique on environmental variables associated with areas with and without sites, indicates that prehistoric cultural resources appear to be concentrated in association with certain definable physical features of the land. In this context, very high densities of resources are likely to occur along the Big Lost River and Birch Creek, atop buttes, and within craters and caves. The Lemhi Mountains, the Lake Terreton basin, and a 1.75-mile- (2,800-meter-) wide zone along the edge of local lava fields probably contain a fairly high density of sites. Within the extensive flows of basaltic lava and along the low foothills of the Lemhi Mountains, site density is classified as moderate, and the lowest density of prehistoric resources probably occurs in the floodplain of the Big Lost River and the alluvial fans emerging from the Birch Creek Valley, in the sinks, and in the recent Cerro Grande lava flow. However, a classification of low or medium density does not eliminate the possibility that significant resources exist in those areas. Although the predictive model has not been tested, it is useful as a planning guide for defining areas most likely to contain archeological resources based on past surveys.

Although there has been no systematic inventory of historically significant facilities associated with the creation and operation of the INEL, a preliminary study indicated that all INEL facilities will require evaluation (Braun et al. 1993). The Experimental Breeder Reactor-I is a National Historic Landmark listed in the National Register of Historic Places. To date, however, few of the other properties have been formally evaluated for eligibility to the National Register. Memoranda of Agreement between DOE, the Idaho State Historic Preservation Office, and the National Advisory Council on Historic Preservation establish that certain structures at Test Area North (DOE 1993b) and Auxiliary Reactor Area (DOE 1993a) are eligible for nomination, and outline specific techniques for preserving the historic value of the areas in conformance with the requirements of the Historic American Building Survey and the Historic American Engineering Record. Other facilities on the INEL site are likely to require similar efforts if DOE schedules them for major modification, demolition, or abandonment.

4.4.2 Native American Cultural Resources

Because Native American people believe the land is sacred, the entire INEL reserve is culturally important to them. Cultural resources, to the Shoshone-Bannock peoples, include all forms of traditional lifeways and usage of all natural resources. This includes not only prehistoric archeological sites, which are important in a religious or cultural heritage context, but also features of the natural landscape, air, plant, water, or animal resources that might have special significance. These resources may be affected by changes in the visual environment (construction, ground disturbance, or introduction of a foreign element into the setting), dust particles, or by contamination. Geographically, the INEL is included within a large territory once inhabited by and still of importance to the Shoshone-Bannock Tribes. Plant resources used by the Shoshone-Bannock Tribes that are located on or near the INEL site are listed in Table 4.4-1. Areas significant to the tribes would include the buttes, wetlands, sinks, grasslands, juniper woodlands, Birch Creek, and the Big Lost River.

Five Federal laws prompt consultation between Federal agencies and Indian Tribes: the National Environmental Policy Act (NEPA 1969), the National Historic Preservation Act (NHPA 1966 as amended), the American Indian Religious Freedom Act (AIRFA 1978), the Archeological Resources Protection Act (ARPA 1979), and the Native American Graves Protection and Repatriation Act (NAGPRA 1990). In accordance with these directives and in consideration of its Native American Policy (DOE 1990a and DOE 1992a), DOE is developing procedures at the INEL for consultation and coordination with the Shoshone-Bannock Tribes of the Fort Hall Reservation. DOE has committed to additional interaction and exchange of information with the Shoshone-Bannock Tribes, and has outlined this relationship in a formal Working Agreement with these tribes (DOE 1992c). In addition, the Cultural Resources Management Plan for the INEL (Miller 1992) and the curation agreement for permanent storage of archaeological materials will be completed by June 1996. The Cultural Resources Management Plan will define procedures for involving the tribes during the planning stages of project development and the curation agreement will provide for the repatriation of burial goods in accordance with NAGPRA.

4.4.3 Paleontological Resources

There are 31 known fossil localities at the INEL site. Available information suggests that the region has relatively abundant and varied paleontological resources. Preliminary analyses suggest that these materials are most likely to occur in association with archeological sites; in areas of basalt flows;

Table 4.4-1. Plants used by the Shoshone-Bannock tribes that are located on or near the INEL.

Plant Family	Type of Use	Location	Abundance
Desert Parsley	medicine, food	scattered over site	common
Milkweed	food, tools	roadsides	scattered, uncommon
Sagebrush	medicine, tools	throughout the site	common, abundant
Balsamroot	food, medicine	around buttes	common but scattered
Thistle	food	scattered throughout site	common but scattered
Gumweed	medicine	disturbed areas	common
Sunflower	medicine, food	roadside	common
Dandelion	food, medicine	throughout site	common
Beggar's Ticks	food	disturbed areas throughout site	common, abundant
Tansymustard	food, medicine	disturbed areas	common
Cactus	food	throughout the site	common, abundant
Honeysuckle	food, tools	Big Southern Butte	common on butte
Goosefoot	food	throughout site	common, abundant
Russian Thistle	food	disturbed areas throughout site	common, abundant
Dogwood	food, medicine, tools	Webb Springs, Birch Creek	common where found
Juniper	medicine, food, tools	throughout site	common to abundant
Gooseberry	food	scattered throughout site	common
Mentha arvensis	medicine	Big Lost River	uncommon
Wild onion	food, medicine, dye	throughout site	common
Caloehortus spp.	food	buttes	common
Fireweed	food	throughout site	common
Pine	food, tools, medicine	Big Southern Butte	common on butte
Douglas Fir	medicine	Big Southern Butte	common on butte
Plantain	medicine, food	throughout site	uncommon
Wildrye	food, tools	throughout site	common, abundant
Indian Ricegrass	food	throughout site	common, abundant
Bluegrass	food, medicine	throughout site	common, abundant
Serviceberry	food, tools, medicine	buttes	common where found
Chokeberry	food, medicine, tools, fuel	buttes	common where found
Wood's Rose	food, smoking, medicine, ritual	Big Lost River, Big Southern Butte	common, abundant
Red Raspberry	food, medicine	Big Southern Butte	uncommon
Willow	medicine	throughout site in moist areas	common
Coyote Tobacco	smoking, medicine	Big Lost River, Webb Springs	uncommon
Cattail	food, tools	sinks, outflow from facilities	uncommon

Source: Andersen et al. (1995).

in deposits of the Big Lost River, Little Lost River, and Birch Creek; in deposits of Lake Terreton and playas; in some wind and sand deposits; and in sedimentary interbeds or lava tubes within local lava flows (Miller 1992).

4.5 Aesthetic and Scenic Resources

4.5.1 Visual Character of the INEL Site

The Bitterroot, Lemhi, and Lost River mountain ranges border the INEL site on the north and west. Persons can see volcanic buttes near the southern boundary of the INEL from most locations on the site and from the Fort Hall Reservation. Most of the INEL site consists of open undeveloped land, covered predominantly by large sagebrush and grasslands (see Section 4.9). Pasture and irrigated farmland border much of the INEL site (see Section 4.2).

Although the INEL has a master plan, it has not established specific visual resource standards. The nine facility areas on the INEL site are generally of low density, look like commercial or industrial complexes, and are spread across the site. Structures in the facility areas range in height from 10 feet to approximately 100 feet (3 to 30 meters). About 90 miles (145 kilometers) of paved public highway run through the INEL site (see Section 4.11). Although many INEL facilities are visible from these highways, most facilities are located more than 0.5 mile (0.8 kilometer) from public roads.

4.5.2 Scenic Areas

The Craters of the Moon National Monument is about 15 miles (24 kilometers) southwest of the INEL site's western boundary. The Monument is located in a designated Wilderness Area, which must maintain Class I (very high) air quality standards or minimal degradation, as defined by the Clean Air Act (CAA 1990; CFR 1990; CFR 1991b). Under Section 169a of the Clean Air Act, air quality includes visibility and scenic view considerations.

Lands adjacent to the INEL under Bureau of Land Management jurisdiction are Visual Resource Management Class II areas (BLM 1984; BLM 1986), which urge preservation and retention of the existing character of the landscape. Lands inside the INEL boundaries are Class III and IV areas, the most lenient classes in terms of modification. The Bureau of Land Management is considering the Black Canyon Wilderness Study Area, which is adjacent to the INEL, for a Wilderness Area designation (BLM 1986); if approved, this would result in an upgrade from Visual Resource Management Class II to a Class I.

Features of the natural landscape have special significance to the Shoshone-Bannock tribes. The visual environment of the INEL site is within the visual range of Fort Hall Reservation.

4.6 Geology

This section describes the geology of the INEL and the surrounding area. Section 4.6.1 characterizes the general geology, while section 4.6.2 describes the natural resources of the area. Sections 4.6.3 and 4.6.4 describe seismic and volcanic hazards, respectively.

4.6.1 General Geology

The site is on the Eastern Snake River Plain (Figure 4.6-1). The Plain forms a broad northeast-trending, crescent-shaped trough with low relief composed primarily of surface basaltic lava flows formed 1.2 million to 2,100 years ago. The Plain features thin, discontinuous, and interbedded deposits of wind-blown loess and sand; water-borne alluvial fan, lacustrine, and floodplain alluvial sediments; and rhyolitic domes formed 1,200,000 to 300,000 years ago (Kuntz et al. 1990)

(Figure 4.6-2). Mountains and valleys of the Basin and Range Province, which trend north to northwest and consist of folded and faulted rocks that are more than 70 million years old, bound the Plain on the north and south. The Yellowstone Plateau bounds the Plain on the northeast. The major episode of Basin and Range faulting began 20 to 30 million years ago and continues today, most recently associated with the October 28, 1983, Borah Peak earthquake [moment magnitude 6.9, magnitude 7.3 on the Richter scale with a resulting peak ground acceleration of 0.022 to 0.078 at the INEL (Jackson 1985)], which occurred along the Lost River fault, approximately 100 kilometers (62 miles) from site facilities and the 1959 Hebgen Lake Earthquake, moment magnitude 7.5, approximately 150 kilometers (93 miles) from the INEL (Figure 4.6-1).

The northeast-trending volcanic terrain of the Plain has a markedly different geologic history and tectonic pattern than the folded and faulted terrain of the northwest-trending Basin and Range. The Basin and Range faults have not been observed on or across the Plain. Four northwest-trending volcanic rift zones, attributed to basaltic eruptions that occurred 4 million to 2,100 years ago, lie across the Plain at the INEL (Bowman 1995; Hackett and Smith 1992; Kuntz et al. 1990).

The seismic characteristics of the Eastern Snake River Plain and the adjacent Basin and Range Province are also different. Earthquakes and active faulting are associated with the Basin and Range tectonic activity. The Plain has historically experienced few and small earthquakes (King et al. 1987; Pelton et al. 1990; WCC 1992; Jackson et al. 1993).

Figure 4.6-1. Location of INEL in context of regional geologic features. **Figure 4.6-2. Lithologic logs of deep drill holes in the INEL area.**

4.6.2 Natural Resources

In 1979 the INEL drilled a geothermal exploration well to 3,159 meters (10,365 feet). Researchers measured a temperature of 142yC (288yF) but identified no commercial quantities of geothermal fluids (IDWR 1980). Mineral resources include several quarries or pits inside the INEL boundary that supply sand, gravel, pumice, silt, clay, and aggregate for road construction and maintenance, new facility construction and maintenance, waste burial activities, and ornamental landscaping cinders. During excavations, DOE might study the gravel pits to characterize the local surficial geology of the site. Outside the site boundary, mineral resources include sand, gravel, pumice, phosphate, and base and precious metals (Strowd et al. 1981; Mitchell et al. 1981). The geologic history of the Plain makes the potential for petroleum production at the INEL very low.

4.6.3 Seismic Hazards

The distribution of earthquakes at and near the INEL from 1884 to 1989 clearly shows that the Plain has a remarkably low rate of seismicity, whereas the surrounding Basin and Range has a fairly high rate (Figure 4.6-3, WCC 1992). The mechanism for faulting and generation of earthquakes in the Basin and Range is attributed to northeast-southwest directed crustal extension.

Several investigators have suggested hypotheses for the low rate of seismic activity within the Plain compared to the activity in both the Centennial Tectonic Belt and the Intermountain Seismic Belt:

- Smith and Sbar (1974) and Brott et al. (1981) suggest that high crustal temperatures beneath the Plain and adjacent region inside the seismic parabola (Figure 4.6-1) result in ductile deformation (aseismic creep), in contrast to the brittle deformation (rock fracture) that occurs in the Basin and Range.
- Anders et al. (1989) suggest that the Plain and the adjacent region inside the seismic parabola (Figure 4.6-1) have increased integrated lithospheric strength. They propose that the presence of mid-crustal basic intrusive rock strengthens the crust so that it is too strong to fracture (see also Smith and Arabasz 1991).

Figure 4.6-3. Earthquakes with magnitudes greater than 2.5 from 1884 to 1989.

- Parsons and Thompson (1991) propose that magma dike injection suppresses normal faulting and associated seismicity by altering the local tectonic stress field. As dikes are injected in volcanic rift zones, they push apart the surrounding rocks and decrease differential stress, thereby preventing earthquakes from occurring.

- Anders and Sleep (1992) propose that the introduction of mantle-derived magma into the midcrust beneath the Plain has decreased faulting and earthquakes by lowering the rate of deformation.

The markedly different tectonic and seismic histories of the Plain and Basin and Range provinces reflect the dissimilar deformational processes acting in each region. Both regions are subjected to the same extensional stress field (Weaver et al. 1979; Zoback and Zoback 1989; Pierce and Morgan 1992; Jackson et al. 1993); however, crustal deformation occurs through dike injection in the Plain and through large-scale normal faulting in the Basin and Range (Rodgers et al. 1990; Parsons and Thompson 1991; Hackett and Smith 1992).

Major seismic hazards include the effects from ground shaking and surface deformation (faulting, tilting). Other potential seismic hazards (e.g., avalanches, landslides, mudslides, soil settlement, and soil liquefaction) are not likely to occur at the INEL because the local geologic conditions are not conducive to them. Based on the seismic history and the geologic conditions, earthquakes greater than moment magnitude 5.5 (and associated strong ground shaking and surface fault rupture) are not likely to occur in the Plain. However, moderate to strong ground shaking from earthquakes in the Basin and Range can affect the INEL. Researchers use patterns of seismicity and locations of mapped faults to assess potential sources of future earthquakes and to estimate levels of ground motion at the site.

The sources and maximum magnitudes of earthquakes that could produce the maximum levels of ground motions at all INEL facilities include the following (WCC 1990; WCC 1992):

- A moment magnitude 7.0 earthquake at the southern end of the Lemhi fault along the Howe and Fallert Springs segments
- A moment magnitude 7.0 earthquake at the southern end of the Lost River fault along the Arco segment
- A moment magnitude 5.5 earthquake associated with dike injection in either the Arco or Lava Ridge-Hell's Half Acre Volcanic Rift Zone and the Axial Volcanic Zone
- A "random" moment magnitude 5.5 earthquake occurring in the Eastern Snake River Plain

Figure 4.6-4 shows a facility-specific example of the relationship of the peak ground acceleration on the INEL to the annual frequency of occurrence of seismic events on various seismic sources in the region, including the four events described above (WCFS 1993). The curves refer specifically to the site of the Idaho Chemical Processing Plant in the south-central INEL and might not apply directly to other INEL areas. Ground motion contributions from seismic sources not shown on Figure 4.6-4 (i.e., Intermountain seismic belt and Yellowstone Region) are significantly smaller because of their distant locations or lower estimated maximum magnitudes. The INEL Natural Phenomena Committee determines INEL seismic design-basis events based on studies such as those performed by Woodward Clyde Consultants (1990) and Woodward Clyde Federal Services (1993).

A maximum horizontal ground surface acceleration of 0.24g at the Idaho National Engineering Laboratory is estimated to result from an earthquake that could occur once every 2,000 years (DOE 1994). The seismic hazard information presented in this EIS is for general seismic hazard comparisons across DOE sites. Potential seismic hazards for existing and new facilities should be evaluated on a facility-specific basis, consistent with DOE orders, standards, and site-specific procedures. Section 5.15 describes the potential impacts of postulated seismic events.

4.6.4 Volcanic Hazards

Volcanic hazards at the INEL can come from sources inside or outside Plain boundaries. These hazards include the effects of lava flows, ground deformation (fissures, uplift, subsidence), volcanic earthquakes (associated with magmatic processes as distinct from earthquakes associated with tectonics), and ash flows or airborne ash deposits (Bowman 1995). Most of the basalt volcanic activity occurred from 4 million to 2,100 years ago in the INEL area. The most recent and closest volcanic eruption occurred 2,100 years ago at the Craters of the Moon, 25 kilometers (15 miles) southwest of the INEL (Kuntz et al. 1992). The rhyolite domes along the Axial Volcanic Zone formed between 1.2 million and 300,000 years ago and have a recurrence interval of about 200,000 years. Therefore, the probability of future dome formation affecting INEL facilities is very low.

Figure 4.6-4. Contribution of the seismic sources to the mean peak acceleration at the Idaho Chemical Processing Plant.

Catastrophic Yellowstone eruptions have occurred three times in the past 2 million years, but the

INEL is more than 160 kilometers (70 miles) from the Yellowstone Caldera rim and high-altitude winds would not disperse Yellowstone ash in the direction of INEL. Due to the infrequency, great distance, and unfavorable dispersal, pyroclastic flows or ash fallout from future Yellowstone eruptions should not impact the INEL.

Basaltic lava flows and eruptions from fissures or vents might occur. Based on a probability analysis of the volcanic history in the Big Southern Butte area (Volcanism Working Group 1990), the conditional probability that basaltic volcanism would affect a south-central INEL location is less than 2.5 y 10-5 per year (once per 40,000 years or longer), where the risk associated with Axial Volcanic Zone volcanism is greatest. The estimated probability of volcanic impact on INEL facilities farther north, where both silicic and basaltic volcanism have been older and less frequent, is less than 10-6 per year (once every million years or longer). The statistics of 116 measured INEL-area lava flow lengths and areas were used to define the two lava flow hazard zones (Figure 4.6-5). The hazard for a particular site within or near a volcanic zone is much lower, typically by an order of magnitude or more, and must be assessed on a site-specific basis (Bowman 1995).

Figure 4.6-5. Map of the INEL showing locations of volcanic rift zones and lava flow hazard zones. 4.7 Air Quality

This section describes the air resources of the INEL site and the surrounding area. The discussion includes the climatology and meteorology of the region, descriptions of nonradiological and radiological air contaminant emissions, and a characterization of existing and projected levels of air pollutants. The analysis includes both existing facilities and those that were expected (at the time the analysis was performed) to be operational before June 1, 1995. Additional detail and background information on the material presented in this section is presented in Appendix F, Section F-3, of Volume 2.

4.7.1 Climatology and Meteorology

The Eastern Snake River Plain climate exhibits low relative humidity, wide daily temperature swings, and large variations in annual precipitation. Average seasonal temperatures measured on the INEL site range from -7.3yC (18.8yF) in winter to 18.2yC (64.8yF) in summer, with an annual average temperature of about 5.6yC (42yF). Temperature extremes range from a summertime maximum of 39.4yC (103yF) to a wintertime minimum of -45yC (-49yF). The annual average relative humidity is 50 percent, with monthly average maximum values ranging from 59 percent in July to 89 percent in February and December, and with monthly average minimum values ranging from 16 percent in June and July to 47 percent in January (Clawson et al. 1989).

Annual precipitation is light, averaging 221.2 millimeters (8.71 inches), with monthly extremes of zero to 127 millimeters (5 inches). The maximum 24-hour precipitation rate is 46 millimeters (1.8 inches). The greatest short-term precipitation rates are attributable primarily to thunderstorms, which occur approximately two or three days per month during the summer. The average annual snowfall is 701 millimeters (27.6 inches), with a maximum of 1,516 millimeters (59.7 inches) and a minimum of 173 millimeters (6.8 inches) (Clawson et al. 1989).

The INEL site is in the belt of prevailing westerlies; however, the mountain ranges bordering the Eastern Snake River Plain normally channel these winds into a southwest wind. Most offsite locations experience the predominant southwest-northeast wind flow of the Eastern Snake River Plain, although subtle terrain features near some locations cause considerable variations from this flow regime. The annual average wind speed measured at the 6.1-meter (20-foot) level at the Central Facilities Area Weather Station is 3.4 meters per second (7.5 miles per hour). Monthly average values range from 2.3 meters per second (5.1 miles per hour) in December to 4.2 meters per second (9.3 miles per hour) in April and May (Clawson et al. 1989). The highest hourly average near-ground wind speed measured onsite is 22.8 meters per second (51 miles per hour) from the west-southwest, with a maximum instantaneous gust of 34.9 meters per second (78 miles per hour) (Clawson et al. 1989). Figure 4.7-1 presents the frequency of wind speed and wind direction at three meteorological monitoring sites on the INEL site from 1988 to 1992. The wind directions presented in the figure are the direction from which the wind blows. The three wind-roses demonstrate the effects of terrain on predominant wind directions and wind speed. The winds at the Test Area North monitoring station are predominantly from the north-northwest, whereas the winds from the other stations are predominantly from the southwest.

Air pollutant dispersion is a result of the processes of transport and diffusion of airborne contaminants in the atmosphere. Transport is the movement of a pollutant in the wind field, while diffusion refers to the process whereby turbulent eddies dilute a pollutant plume. The temperature gradient of the atmosphere (i.e., the change in temperature with altitude) can restrict or enhance the vertical diffusion of pollutants. Lapse rate conditions, which tend to enhance vertical diffusion, occur slightly less than 50 percent of the time. Conversely, thermal stratification or inversion conditions, which inhibit vertical diffusion, occur slightly more than 50 percent of the time. The height to which the pollutants can freely diffuse is the mixing depth, while the layer of air from the ground to the mixing depth is the mixed layer. Estimates of the monthly average depth of the mixed layer range from 400 meters (1,312 feet) in December to 3,000 meters (9,843 feet) in July. With calm winds and mostly clear skies, nocturnal inversions begin forming after sunset and dissipate about 1 to 2 hours after sunrise. These inversions are often ground-based, meaning the atmospheric temperature increases with height from the ground (Clawson et al. 1989).

Other than thunderstorms, severe weather is uncommon. Five funnel clouds (tornadoes not touching the ground) and no tornadoes were reported on the site between 1950 and 1988. Visibility in the region is good because of the low moisture content of the air and minimal sources of visibility-reducing pollutants. From Craters of the Moon National Monument, the seasonal visual range is from 130 to 155 kilometers (81 to 97 miles) (Notar 1993).

4.7.2 Air Quality

4.7.2.1 Nonradiological Air Quality.

The INEL is in the Eastern Idaho Intrastate Air Quality Control Region (AQCR 61). Neither the INEL nor any of the surrounding counties is designated as a nonattainment area (CFR 1992b) for the National Ambient Air Quality Standards (CFR 1991b). Ambient air quality data monitored in the vicinity of the INEL indicate that the site is in compliance with applicable air quality standards (DOE 1991a).

Figure 4.7-1. Depiction of annual average wind direction and speed at INEL meteorological monitoring stations.

The Clean Air Act (CAA 1990) contains requirements to prevent the deterioration of air quality in areas designated to be in attainment with the ambient air quality standards. These requirements are administered through a program that limits the increase in specific air pollutants above the levels that existed in what has been termed a baseline (or starting) year, which is 1977. The requirements specify maximum allowable ambient pollutant concentration increases or increments. They specify increment limits for pollutant level increases for the nation as a whole (Class II areas) and prescribe more stringent increment limits (as well as ceilings) for designated national resources, such as national forests, parks, and monuments (Class I areas). Three areas in the INEL vicinity are Prevention of Significant Deterioration Class I ambient air quality areas: Craters of the Moon Wilderness Area, approximately 53 kilometers (33 miles) to the west-southwest; Yellowstone National Park, approximately 143 kilometers (89 miles) to the northeast; and Grand Teton National Park, approximately 145 kilometers (90 miles) to the east-northeast.

DOE evaluates proposed new and modified sources of emissions at INEL to determine the net emissions increase of all pollutants. The INEL is considered a major source, because facility-wide emissions of specific regulated air contaminants exceed 227 metric tons (250 tons) per year. Therefore, a Prevention of Significant Deterioration analysis must be performed for all significant emission increases of specified regulated pollutants. Levels of significance for net emission increases range from very small quantities (less than 1 pound) for beryllium up to 91 metric tons (100 tons) per year for carbon monoxide. Their significance is dependent on the toxicity of the substance. For radionuclides, significance means any increase in emissions that would result in an offsite dose of 0.1 millirem per year or greater.

Ambient air quality standards for Idaho are the same as the National Ambient Air Quality Standards but include total suspended particulates and fluorides. The Idaho Department of Health and Welfare (IDHW) also has ambient concentration limits for hazardous and toxic air pollutants. Table 4.7-1 lists emission rates of criteria and hazardous and toxic air pollutants.

The types and amounts of nonradiological emissions from INEL facilities and activities are **similar to those from other industrial complexes that are the same sizes as the INEL.** Combustion sources such as boilers and emergency generators emit both criteria and toxic pollutants. Other sources include chemical processing operations, transportation, waste management activities, and research laboratories.

Table 4.7-1. Baseline annual average and maximum hourly emission rates of nonradiological air pollutants at the INEL.

Pollutant	Annual average (kg/yr)[b,c]	Maximum hourly (kg/hr)[b]
Criteria pollutants		
Carbon monoxide (CO)	301,000	177
Lead (Pb)	11	0.085
Nitrogen dioxide (NO_2)	744,000	545
Particulate matter (PM_{10})[d]	302,000	230
Sulfur dioxide (SO_2)	202,000	136
Hazardous/toxic air pollutants[e]		
Acetaldehyde	31	0.39
Ammonia	1,600	3.4
Arsenic	4.2	9.0 y 10-4
Benzene	370	16
1,3-Butadiene	220	0.8
Carbon tetrachloride	28	0.08
Chloroform	1.9	5.5 y 10-3
Chromium - trivalent	3.1	2.5 y 10-3
Chromium - hexavalent	0.4	6.2 y 10-4
Cyclopentane	350	0.58
Dichloromethane	620	0.29
Formaldehyde	960	8.9
Hydrazine	8.3	9.5 y 10-4
Hydrochloric acid	1,500	0.34
Mercury	200	0.023
Napthalene	16	2.2
Nickel	270	0.057
Nitric acid	1,500	1.7
Phosphorous	56	0.024
Potassium hydroxide	990	0.24
Propionaldehyde	62	0.24
Styrene	4.7	0.74
Tetrachlorethylene	980	0.11
Toluene	580	56
Trichloroethylene	4.7	0.013
Trimethylbenzene	87	12

a. Source: Volume 2, Table 4.7-2.
b. To convert kilograms to pounds, multiply by 2.2.
c. Annual average values include actual emissions plus projected increases from facilities that will become opertional after the baseline year.
d. It is conservatively assumed that all particulate matter is PM10 (less than 10 microns in diameter).
e. Hazardous/toxic air pollutants that are listed in State of Idaho regulations and are emitted in levels that exceed screening criteria.

Table 4.7-2 compares the INEL contribution to air quality to applicable standards and guidelines. This assessment modelled the INEL air emissions inventory for 1990 using the methodology approved by the U.S. Environmental Protection Agency to predict the maximum ground-level concentration that would occur at or beyond the site boundary for each regulated pollutant (EPA 1993b). The Industrial Source Complex-2 model primarily assessed criteria pollutants, and the SCREEN model assessed toxic air pollutants. The SCREEN model incorporates meteorological data that tend to overestimate impacts, and is useful for identifying cases that require additional, more refined assessments. The baseline concentrations listed in Table 4.7-2 are the sums of the following factors: the concentrations resulting from potential impacts from current operations and the concentrations resulting from the construction or operation of planned upgrades or modifications before the implementation of the proposed actions described in Section 5.7. Background concentrations have not been included because (a) reliable data on background levels in the INEL environs are not available for most pollutants and (b) background levels are low and are more than offset by the use of the maximum (as opposed to actual) baseline. The baseline concentrations represent the maximum calculated concentration occurring at public access locations (site boundary, public roads, and Craters of the Moon Wilderness Area). A comparison of the baseline concentrations to applicable Federal and state criteria pollutant and hazardous/toxic air pollutant guidelines and regulations shows that air quality at INEL is in compliance with those guidelines and regulations. The 24-hour total suspended particulate background concentration is listed as 40 micrograms per cubic meter, which is the same as the annual geometric mean value. The annual sources include chemical processing operations, transportation, waste management activities, and research laboratories.

4.7.2.2 Radiological Air Quality. The major source of radiation exposure in the Eastern Snake River Plain is from natural background radiation sources such as cosmic rays; radioactivity naturally present in soil, rocks, and the human body; and airborne radionuclides of natural origin (such as radon). Sources of radioactivity related to INEL operations include research and training reactors, spent nuclear fuel testing and stabilization, irradiated material and fuel examination, nuclear waste treatment and storage, and depleted uranium armor production.

Radioactive emissions from INEL facilities include the noble gases (argon, krypton, and xenon) and iodine; particulate fission products such as rubidium, strontium, and cesium; radionuclides formed

Table 4.7-2. Comparison of baseline ambient air concentrations with most stringent applicable regulations and guidelines at the INEL.

Pollutant	Averaging time	Most stringent regulation or guideline (-g/m3)a,b,c	Maximum baseline concentration (-g/m3)	Percent of standard
Criteria pollutants				
Carbon monoxide (CO)	8-hour	10,000	280	2.8
	1-hour	40,000	610	1.5
Lead (Pb)	Calendar Quarter	1.5	0.001	<0.1
Nitrogen dioxide (NO2)	Annual	100	4	4
Particulate matter (PM10)	Annual	50	5	10
	24-hour	150	80	53
Sulfur dioxide (SO2)	Annual	80	6	7.5
	24-hour	365	140	37
	3-hour	1,300	580	45
Hazardous/toxic air pollutants				
Acetaldehyde	Annual	4.5 y 10-1	1.1 y 10-2	2
Ammonia	Annual	1.8 y 102	6.0 y 100	3
Arsenic	Annual	2.3 y 10-4	9.0 y 10-5	39
Benzene	Annual	1.2 y 10-1	2.9 y 10-2	24
Butadiene	Annual	3.6 y 10-3	1.0 y 10-3	28
Carbon Tetrachloride	Annual	6.7 y 10-2	6.0 y 10-3	9
Chloroform	Annual	4.3 y 10-2	4.0 y 10-4	<1
Chromium - hexavalent	Annual	8.3 y 10-5	6.0 y 10-5	72
Chromium - trivalent	Annual	5.0 y 100	3.6 y 10-2	<1
Cylclopentane	Annual	1.7 y 104	2.7 y 10-0	<1
Formaldehyde	Annual	7.7 y 10-2	1.2 y 10-2	16
Hydrazine	Annual	3.4 y 10-4	1.0 y 10-6	<1
Hydrochloric acid	Annual	7.5 y 100	9.8 y 10-1	13
Mercury	Annual	1.0 y 100	4.2 y 10-2	4
Methylene Chloride	Annual	2.4 y 10-1	6.0 y 10-3	3
Napthalene	Annual	5.0 y 102	1.8 y 101	4
Nickel	Annual	4.2 y 10-3	2.7 y 10-3	65
Nitric Acid	Annual	5.0 y 101	6.4 y 10-1	1

Table 4.7-2. (continued).

Pollutant	Averaging time	Most stringent regulation or guideline (-g/m3)a,b,c	Maximum baseline concentration (-g/m3)	Percent of standard
Perchloroethylene	Annual	2.1 y 100	1.1 y 10-1	5
Phosphorous	Annual	1.0 y 100	3.0 y 10-1	30
Potassium hydroxide	Annual	2.0 y 101	2.0 y 10-1	1
Proprionaldehyde	Annual	4.3 y 100	3.0 y 10-1	7
Styrene	Annual	1.0 y 103	1.3 y 100	<1
Toluene	Annual	3.8 y 103	3.7 y 102	10
Trichloroethylene	Annual	7.7 y 10-2	9.7 y 10-4	1
Trimethylbenzene	Annual	1.2 y 103	1.0 y 102	8

a. CFR (1991b).
b. IDHW (1994); the ambient standards for the criteria pollutants are the same as the NAAQS.
c. Standards cited for hazardous/toxic air pollutants are for all new sources constructed or modified since May 1, 1994, under State of Idaho Regulations for the Control of Air Pollution in the State of Idaho (IDHW 1994).
Source: Volume 2, Section 4.7.

by neutron activation such as tritium (hydrogen-3), carbon-14, and cobalt-60; and very small quantities (less than 6 y 10-4 curies per year) of heavy elements such as uranium, thorium, plutonium, and their decay products. Historically, the radionuclide with the highest emission rate is the noble gas krypton-85, which is released primarily by the chemical reprocessing of spent nuclear fuel at the Idaho Chemical Processing Plant. Fuel reprocessing also releases small amounts (less than 0.1 curie per year) of iodine-129, which is of concern because of its long half-life (16 million years) and biological properties (iodine isotopes tend to accumulate in the human thyroid). Reactor operations release noble gas isotopes with short half-lives, including argon-41 and isotopes of xenon (primarily xenon-133, -135, and -138). Other activities at the INEL, including waste management operations, result in very low levels of airborne radionuclide emissions (less than 1 y 10-4 curie per year). Table 4.7-3 summarizes airborne radionuclide emissions from INEL facility areas, plus estimated emissions from projects expected, at the time of the analysis was performed, to become operational before June 1, 1995.

Radioactivity released to the atmosphere can result in human exposure through a number of pathways, including inhalation, external exposure, and ingestion. DOE conducts physical

Table 4.7-3. Summary of airborne radionuclide emissions from INEL facility areas (curies per year).

Facility	Tritium/ carbon-14	Iodines	Noble gases	Mixed fission and activation productsb	U/Th/TRUc
Argonne National Laboratory-West	1.0 y 102	-d	1.3 y 104	8.1 y 10-4	1.8 y 10-6
Central Facilities Area	2.6 y 100	5.0 y 10-7	-	1.9 y 10-5	9.6 y 10-7
Idaho Chemical Processing Plant	4.3 y 101	6.4 y 10-2	1.0 y 104	3.6 y 10-2	9.4 y 10-9
Naval Reactors Facility	1.9 y 10-1	6.3 y 10-6	5.7 y 10-1	5.6 y 10-5	-
Power Burst Facility/Waste Experimental Reduction Facility	4.9 y 101	-	-	1.3 y 100	9.8 y 10-3
Radioactive Waste Management Complex	-	-	-	2.6 y 10-5	4.2 y 10-6
Test Area North	1.2 y 10-1	-	-	5.6 y 10-6	1.5 y 10-5
Test Reactor Area	1.6 y 102	1.6 y 10-2	3.3 y 103	3.0 y 100	1.8 y 10-6
INEL total	2.1 y 103	1.1 y 10-1	1.2 y 105	5.6 y 100	1.0 y 10-2

a. With the exception of the Idaho Chemical Processing Plant, emissions estimates are based on 1991 operations. Idaho Chemical Processing Plant emissions are based on 1993 emissions but are scaled upward to reflect operation of the New Waste Calcining Facility at maximum permitted levels. Anticipated projects in the baseline include the Waste Experimental Reduction Facility (compacting and sizing operations but not incineration), Argonne National Laboratory-West Fuel Cycle Facility, and Portable Water Treatment Unit, as described in Appendix F of Volume 2.

b. Mixed fission and activation products that are primarily particulate in nature (for example, cobalt-60, strontium-90, and cesium-137).

c. U/Th/TRU = Radioisotopes of uranium, thorium, or transuranic elements such as plutonium, americium, and neptunium.

d. A dash (-) indicates that the emissions for this group are negligibly small or zero.

Source: Volume 2, Table 4.7-1.

measurements (ambient air monitoring) and uses calculation techniques (atmospheric dispersion modeling) to assess existing levels of radiation (both cosmic and manmade) in and near the site, and to assess doses to workers and the surrounding population.

The offsite population can receive a radiation dose as a result of radiological conditions directly attributable to existing INEL operations. DOE assesses such a dose for a maximally exposed individual and for the population as a whole. The maximally exposed individual is a hypothetical person whose habits and proximity to the site are such that the person would receive the highest dose projected to result from sitewide radioactive emissions. The calculated annual dose to this individual as a result of current and anticipated sitewide emissions is 0.05 millirem (Section 4.7 to Volume 2). This value is a small fraction of both the National Emission Standards for Hazardous Air Pollutants dose limit of 10 millirem per year (CFR 1992a) and the dose received from natural background sources of 351 millirem per year (Section 4.7 to Volume 2). Figure 4.7-2 compares these dose rates.

The collective annual dose to the surrounding population, determined using 1990 U.S. Census Bureau data for the total population residing within an 80-kilometer (50-mile) radius from each facility on the site, is about 0.3 person-rem (Section 4.7 to Volume 2). This value is small in comparison to the annual dose received by the same population from background sources, which is more than 40,000 person-rem (Section 4.7 to Volume 2).

Workers at each major INEL facility can receive radiation exposures. DOE has based its assessment of the dose to these workers on contributions from sources at each facility and those expected to become operational before June 1, 1995. The results of this assessment indicate that the maximum dose received by a worker at any onsite area is about 4.3 millirem per year (Section 4.7 to Volume 2), well below the National Emissions Standard for Hazardous Air Pollutants dose limit of 10 millirem per year. The standard applies to the highest exposed member of the public, and is not applicable to workers. However, it is the most restrictive limit for airborne releases and provides a useful comparison. This dose value of 4.3 millirem per year includes the maximum projected operation of the Portable Water Treatment Unit at the Power Burst Facility Area. However, that operation would be temporary (1 to 2 years) and is not representative of a permanent increase in the baseline. If this facility were not included, the baseline dose to the worker would be about 0.2 millirem per year.

Figure 4.7-2. Comparison of dose to maximally exposed individual (MEI) to the National Emission Standard for Hazardous Air Pollutants (NESHAP) dose limit and the dose from background sources.

4.8 Water Resources

This section describes existing regional and site hydrologic conditions and discusses the quality of surface and subsurface water and water use and rights. The subsurface water section also describes the vadose zone (or unsaturated zone and perched water bodies) located between the land surface and the water table.

4.8.1 Surface Water

Other than surface-water bodies formed from accumulated runoff during snowmelt or heavy precipitation and manmade infiltration and evaporation ponds, there is little surface water at the site.

The following sections discuss regional drainage conditions, local runoff, floodplains, and surface-water quality. Figure 4,8-1 supports discussions in this section.

4.8.1.1 Regional Drainage. The INEL is in the Pioneer Basin, a closed drainage basin that

includes three main surface-water bodies--the Big and Little Lost Rivers and Birch Creek. These water bodies drain mountain watersheds directly west and north of the site. However, most of the surface-water flow is diverted for irrigation before it reaches site boundaries (Barraclough et al. 1981), resulting in little or no flow for several years inside the site boundaries (Pittman et al. 1988).

The Big Lost River drains approximately 3,755 square kilometers (1,450 square miles) of land before reaching the site. Approximately 48 kilometers (30 miles) upstream of Arco, Idaho, Mackay Dam controls and regulates the flow of the river, which continues southeast past the towns of Moore and Arco and onto the Eastern Snake River Plain. The river channel then crosses the southwestern boundary of the site, where the INEL Diversion Dam controls surface-water flow. During heavy runoff events, the dam diverts surface water to a series of natural depressions, designated as spreading areas. The Big Lost River continues northeasterly across the site to an area of natural infiltration basins (playas or sinks) near Test Area North. In dry years, surface water does not usually reach the western boundary of the site, and because the INEL is located in a closed drainage basin, surface water never flows off the site.

Birch Creek drains an area of approximately 1,943 square kilometers (750 square miles). In the summer, upstream of the site, surface water from Birch Creek is diverted to provide irrigation and

Figure 4.8-1. Selected facilities and predicted inundation map for probable maximum flood-induced overtopping failure of Mackay Dam at INEL.

to produce hydropower. In the winter, water flow crosses the northwest corner of the site, entering a manmade channel 6.4 kilometers (4 miles) north of Test Area North, where it then infiltrates into channel gravels.

The Little Lost River drains an area of approximately 1,826 square kilometers (705 square miles). Strearnflow is diverted for irrigation north of Howe, Idaho. Surface water from the Little Lost River has not reached the site in recent years; however, during high stream flow years, water will reach the site and infiltrate into the subsurface (E(3&G 1984).

4.8.1.2 Local Runoff. Surface water generated from local precipitation will flow into

topographic depressions (lower elevations than the surrounding terrain) on the site. This surface water either evaporates or infiltrates into the ground, increasing subsurface saturation and enhancing subsurface migration (Wilhelmson et al. 1993).

Localized flooding can occur at the site when the ground is frozen and melting snow combines with heavy spring rains. Test Area North was flooded in 1969 (Koslow and Van Haaften 1986), In 1969 extensive flooding caused by snowmelt occurred in the lower Birch Creek Valley (Koslow 1984) Studies have shown that both the 25- and 100-year, 24-hour rainfall/snowmelt storm event could cause flooding within the Radioactive Waste Management Complex (Dames & Moore 1992). The drainage system, including dikes and erosion prevention features designed to mitigate potential surface water flooding, are being upgraded.

4.8.1.3 Floodplains. Intermittent surface-water flow and the INEL Diversion Dam (built in

1958 and enlarged in 1984) have effectively prevented flooding from the Big Lost River onto the site. However, onsite flooding from the river could occur if high water in the Mackay Dam or the Big Lost River were coupled with a darn failure. Koslow and Van Haaften (1986) examined the consequences of structural failure of the Mackay Dam due to a seismic event, coupled with a probable maximum flood (the largest flood assumed possible in an area), This scenario predicts flood waters overtopping the INEL Diversion Dam and spreading at the Idaho Chemical Processing Plant, Naval Reactors Facility, and the Test Area North Loss-of-Fluid Test Facility (Figure 4.8-1). In the event of a combined Mackay Dam failure and a 100-year flood (flood that occurs on an average of every

100 years), flooding along the Big Lost River would also occur, with low velocities and water depths on the INEL (Koslow and Van Haaften 1986). The area inundated under the Mackay Dam failure scenarios probably would use more than the 100- or 500-year floodplains for the Big Lost River at the INEL. A 100-year floodplain study for the INEL is in progress.

4.8.1.4 Surface-Water Ouality, Water quality in the Big and Little Lost Rivers and Birch

Creek is similar and has not varied a great deal over the period of record. Measured physical, chemical, and radioactive parameters have not exceeded applicable drinking water quality standards. Chemical composition is determined primarily by the mineral composition of the rocks in the mountain ranges northwest of the site and by the chemical composition of irrigation water in contact with the surface water (Robertson et al. 1974; Bennett 1990).

Site activities do not directly affect the quality of surface water outside the site because discharges from site facilities are to manmade seepage and evaporation basins or stormwater injection wells. Effluents are not discharged to natural surface waters. In addition, surface water does not flow directly off the site (Hoff et al. 1990). However, water from the Big Lost River, as well as seepage from evaporation basins and stormwater injection wells, does infiltrate the Snake River Plain Aquifer (Robertson et al. 1974; Wood and Low 1988; Bennett 1990). These areas are inspected, monitored, and sampled as stipulated in the INEL Stormwater Pollution Prevention Program (DOE-ID 1 993b).

4.8.2 Subsurface Water

Subsurface water at the site occurs in the Snake River Plain Aquifer and the vadose zone. This section describes regional and local hydrogeologic conditions, vadose zone hydrology, perched water, and subsurface-water quality. Generally, the term "groundwater" refers to usable quantities of water that enter freely into wells under confined and unconfined conditions within an aquifer (Driscoll 1989).

4.8.2. 1 Regional Hydrogeology. The INEL overlies the Snake River Plain Aquifer, the

largest aquifer in Idaho (Figure 4.8-2). This aquifer underlies the Eastern Snake River Plain and covers an area of approximately 24,900 square kilometers (9,611 square miles). Groundwater in the aquifer generally flows south and southwestward across the Snake River Plain. The estimated water storage in the aquifer is 2.5 x 1012 cubic meters (2 billion acre-feet, which is about the same as the volume of water contained in Lake Erie) (Robertson et al. 1974). A typical irrigation well can yield as much as 13.9 x 106 cubic meters (3.7 x 10(9) gallons) per year of water if pumped every day (Garabedian 1989). The Snake River Plain Aquifer is among the most productive aquifers in the nation.

The drainage basin recharging the Snake River Plain Aquifer covers an area of approximately 90,643 square kilometers (35,000 square miles). The aquifer is recharged by infiltration of irrigation

Figure 4.8-2. Location of the INEL, Snake River Plain, and generalized groundwater flow direction of the Snake River Plain Aquifer.

water, seepage from stream channels and canals, underflow from tributary stream valleys extending into the watershed, and direct infiltration from precipitation (Garabedian 1989). Most recharge occurs in surface water-irrigated areas and along the northeastern margins of the plain. Groundwater discharges primarily from the aquifer through springs that flow into the Snake River and from pumping for irrigation. Major springs and seepages that flow from the aquifer are located near the American Falls Reservoir (southwest of Pocatello) and the Thousand Springs area between Milner Dam and King Hill (near Twin Falls).

4.8.2.2 Local Hydrogeology. The INEL site covers 2,305 square kilometers (890 square

miles) of the north-central portion of the Snake River Plain Aquifer. Depth to groundwater from the land surface at the site ranges from approximately 61 meters (200 feet) in the north to over 274 meters (900 feet) in the south (Pittman et al. 1988) (see Figure 4.8-3). Groundwater flow is generally toward the south-southwest, and the upper surface is primarily unconfined (not overlain by impermeable soil or bedrock). However, the aquifer behaves as if it were partially confined because of localized geologic conditions. The occurrence and movement of groundwater in the aquifer depends on the geologic setting and the recharge and discharge of water within that setting. Most of the aquifer consists primarily of numerous relatively thin, basaltic lava flows with interbedded sediments extending to depths of 1,067 meters (3,500 feet) below the land surface (Irving 1993). Most of the groundwater migrates horizontally through fractured, basaltic interflow zones (broken and rubble zones) that occur at various depths. Water also migrates vertically along joints and the interfingering edges of interflow zones (Garabedian 1986). Sedimentary interbeds restrict the vertical movement of groundwater. The variability in how the aquifer stores and transmits water increases the difficulty in aquifer investigations and modeling.

The rate at which water moves through the ground depends on the hydraulic gradient (change in elevation and pressure with distance in a given direction) of the aquifer, the effective porosity (percentage of void spaces), and hydraulic conductivity (capacity of a porous media to transport water) of the soil and bedrock. Because aquifer porosity and hydraulic conductivity decrease with depth, most of the water in the aquifer moves through the upper 61 to 152 meters (200 to 500 feet) of the basalts. Estimated flow rates within the aquifer range from 1.5 to 6.1 meters (5 to 20 feet) per day (Barraclough et al. 1981).

The aquifer's ability to transmit water (transmissivity), and its ability to store water (storativity) are important physical properties of the aquifer. In general, the hydraulic characteristics of the aquifer enable the easy transmission of water, particularly in the upper portions.

Figure 4.8-3. Hydrostratigraphy scross the INEL and water table surface.

Recharge to the aquifer originates off the site from precipitation in the mountains to the west and north. Most of the inflow to the aquifer results from the underflow of groundwater along alluvial-filled valleys adjacent to the Eastern Snake River Plain and adjacent surface-water drainages (i.e., Big and Little Lost Rivers and Birch Creek). In addition, recharge at the site is related to the amount of precipitation, particularly snowfall, for a given year (Barraclough et al. 1981).

4.8.2.3 Vadose Zone Hydrology The vadose (unsaturated) zone extends from the land

surface down to the water table. Within the vadose zone, water and air occupy openings in the geologic materials. Subsurface water in the vadose zone is referred to as vadose water. At the site this complex zone consists of surface sediments (primarily clay and silt, with some sand and gravel) and many relatively thin basaltic lava flows, with some sedimentary interbeds. Thick surficial deposits occur in the northern part of the site, which thin to the south where basalt is exposed at the surface.

The vadose zone protects the groundwater by filtering many contaminants through adsorption, buffering dissolved chemical wastes, and slowing the transport of contaminated liquids to the aquifer. The vadose zone also protects the aquifer by storing large volumes of liquid or dissolved contaminants released to the environment through spills or migration from disposal pits or ponds, allowing natural decay processes to occur.

Travel times for water through the vadose zone are important for an understanding of contaminant movement. The flow rates in the vadose zone depend directly on the extent of fracturing, the percentage of sediments versus basalt, and the moisture content of vadose zone material. Flow increases under wetter conditions and slows under dryer conditions.

4.8.2.4 Perched Water. Locally, saturated conditions that exist above the water table are

called perched water. Perched water occurs when water migrates vertically and laterally from the surface until it reaches an impermeable layer (Irving 1993). As perched water spreads laterally, sometimes for hundreds of meters, it moves over the edges of the impermeable layer and continues downward. Several perched water bodies can form between the land surface and the water table.

In general, perched water bodies slow the downward migration of fluids that infiltrate into the vadose zone from the surface because the downward flow is not continuous. The occurrence of perched water at the site is related to the presence of disposal ponds or other surface-water bodies, which studies have detected at the Idaho Chemical Processing Plant, Test Reactor Area, and Test Area North. For example, a 1986 field study at the Idaho Chemical Processing Plant showed that perched water occurs in three areas at possibly three depth zones, ranging from approximately 9 meters (30 feet) to 98 meters (322 feet) below the ground surface and extending laterally as much as 1 ,097 meters (3,600 feet). In general, the chemical concentrations, shape, and size of these bodies have fluctuated over time in response to the volume of water discharged to the infiltration ponds (Irving 1993).

4.8.2.5 Subsurface Water Quality. Natural water chemistry and contaminants originating at

the site affect subsurface water quality. The INEL Groundwater Protection Management Program conducts monitoring programs. This program collects samples from surface water, perched water, and aquifer wells to identify contaminants and contaminant migration to and within the aquifer.

4.8.2,5.1 Natural Water Chemistry - Several factors determine the natural groundwater

chemistry of the Snake River Plain Aquifer beneath the site. These factors include the weathering reactions that occur as water interacts with minerals in the aquifer and the chemical composition of (1) groundwater originating outside the site; (2) precipitation falling directly on the land surface; and (3) streams, rivers, and runoff infiltrating the aquifer (Wood and Low 1986, 1988). The chemistry of the groundwater is different, depending on the source areas. For example, groundwater from the northwest contains calcium, magnesium, and bicarbonate leached from sedimentary rocks, and groundwater from the east contains sodium, fluorine, and silicate resulting from contact with volcanic rocks (Robertson et al. 1974).

Although the natural chemical composition of groundwater beneath the site does not exceed the Environmental Protection Agency drinking water standards for any component, the natural chemistry affects the mobility of contaminants introduced into the subsurface from INEL activities. Many dissolved contaminants adsorb (or attach) to the surface of rocks and minerals in the subsurface, thereby retarding the movement of contaminants in the aquifer and inhibiting further migration of contamination. However, many naturally occurring chemicals compete with contaminants for adsorption sites on the rocks and minerals or react with contaminants to reduce their attraction to rock and mineral surfaces.

4.8.2.5.2 Groundwater Quality - Previous waste discharges to unlined ponds and deep

wells have introduced radionuclides, nonradioactive metals, inorganic salts, and organic compounds to the subsurface.

Table 4.8-1 summarizes the highest detected concentrations of contaminants observed in the aquifer between 1987 and 1992, concentrations near the site boundary, Environmental Protection **Agency maximum contaminant levels, and DOE Derived Concentration Guides.** The following paragraphs discuss each category of contaminants and comparisons of observed concentrations to maximum contaminant levels.

Table 4.8-1. Highest dtected contaminant concentrations in groundwater at the Idaho National Engineering Laboratory (1987 to 1992).

Radionuclides - In general, radionuclide concentrations in the Snake River Plain Aquifer beneath the site have decreased since the mid-1980s because of changes in disposal practices, radioactive decay, adsorption of radionuclides to rocks and minerals, and dilution by natural surface water and groundwater entering the aquifer (Pittman et al. 1988; Orr and Cecil 1991; Bargelt et al. 1992). Radionuclides released and observed in the soil and groundwater include tritium, strontium-90, iodine-129, cobalt-60, cesium-137, plutonium-238, plutonium-239/240, and americium-241 (Golder Associates 1994). Most of these radionuclides have been observed at the Idaho Chemical Processing

Plant and Test Reactor Area facility areas. However, radionuclides have also been observed in the Test Area North disposal well.

Concentrations of radionuclides in the aquifer have decreased over time. This decrease is attributed to reduced discharges, adsorption, radioactive decay, and improved waste management practices. As of 1992, concentrations of iodine-l29, cobalt-60, tritium, strontiurn-90, and cesium-137 had exceeded the EPA maximum contaminant levels for radionuclides in drinking water in localized areas inside the INEL boundary. Currently, there are no individual maximum contaminant levels for plutonium-238, plutonium-239, plutonium-240, and americium-24 1. However, these radionuclides have not been detected above the established limits for gross radioactivity or the proposed adjusted gross alpha activity maximum contaminant level for drinking water (Golder Associates 1994; Mann et al. 1988; Orr and Cecil 1991).

Extremely low concentrations of iodine- 129 and tritium have migrated outside site boundaries. In 1992, iodine- 129 concentrations were well below the maximum contaminant levels in two wells approximately 6 and 13 kilometers (4 and 8 miles) south of the site boundary (Mann 1994). Tritium concentrations were much below maximum contaminant levels just south of the site boundary in 1985. By 1988 the tritium plume encompassed by the 500 picocurie per liter contour was back inside the site boundary, and its size has continued to decrease (Pittman et al. 1988; Otr and Cecil 1991; Orr et al. 1991). Cobalt-60, strontium-90, cesium-i 3?, plutonium-238, plutonium-240!241, and americium-241 have not been detected outside the site boundaries.

Nonradioactive Metals - The INEL has released sodium, chromium, lead, and mercury on the site and into the subsurface through unlined ponds and deep wells. Of these metals, the INEL released sodium in the greatest quantity from waste treatment processes; however, sodium is not toxic and does not have an established maximum contaminant level. In 1988 chromium concentrations exceeding the maximum contaminant level were measured near the Test Reactor Area. Lead and mercury have occurred at concentrations below the maximum contaminant level near the Idaho Chemical Processing Plant (Orr and Cecil 1991).

Inorganic Salts - Human activities at the site have released chloride, sulfate, and nitrate into the subsurface. Although chloride and sulfate releases have occurred, only nitrate has exceeded maximum contaminant levels (near the Idaho Chemical Processing Plant in 1981). Disposal of nitrates to the injection well and infiltration ponds at the Idaho Chemical Processing Plant account for the elevated nitrate levels in the central portion of the site. By 1988 the levels of nitrate decreased to below the maximum contaminant level. Irrigation in the Mud Lake area might be causing these contaminants to enter the northeastern portion of the site in concentrations comparable to those in nearby irrigated areas (Orr et al. 1991; Robertson et al. 1974; Edwards et al. 1990).

Organic Compounds - Concentrations of volatile organic compounds have been detected in the aquifer beneath the site. However, many of these compounds were detected at amounts below the detection limit (0.002 milligram per liter), or two parts per billion, which is the lowest concentration at which a specific analytical method can detect a contaminant. However, concentrations of the following compounds exceeding the maximum contaminant levels have occurred in and near the Test Area North disposal well: carbon tetrachloride, chloroform, l,2-cis-dichloroethylene, 1,1 -dichloroethylene, 1 ,2-trans-dichloroethylene, trichloroethylene, tetrachloroethylene, and vinyl chloride (Leenheer and Bagby 1982; Mann and Knobel 1987; Mann 1990; Liszewski and Mann 1992).

4.8.2.5.3 Perched Water Quality - Wastewater discharges from INEL operations have

infiltrated into the vadose zone and created most of the perched water beneath the site. Studies have detected elevated concentrations of the following contaminants in samples: tritium, cesium-l37, cobalt-60, chromium, and sulfate concentrations in deep perched water near the Test Reactor Area, and strontium-90 in perched water near the Idaho Chemical Processing Plant and at Test Area North (Irving 1993; Schafer-Perini 1993). DOE has not yet measured potential concentrations of contaminants in all INEL perched water bodies. In general, the chemical concentrations, shape, and size of these bodies have fluctuated over time in response to the volume of water discharged to the infiltration ponds.

4.8.3 Water Use and Rights

The INEL does not withdraw or use surface water for site operations, nor does it discharge effluents to natural surface water. However, the three surface-water bodies at or near the site (Big and Little Lost Rivers and Birch Creek) have the following designated uses: agricultural water supply, cold-water biota, salmonid spawning, and primary and secondary contact recreation. In addition, waters in the Big Lost River and Birch Creek have been designated for domestic water supply and as special resource waters.

Groundwater use on the Snake River Plain includes irrigation, food processing and aquaculture, and domestic, rural, public, and livestock supply. Water use for the upper Snake River drainage basin and the Snake River Plain Aquifer was 16.4 billion cubic meters (4.3 trillion gallons) per year in 1985, which was more than 50 percent of the water used in Idaho and approximately 7 percent of agricultural withdrawals in the nation. Most of the water withdrawn from the Eastern Snake River Plain [1.8 billion cubic meters (0.47 trillion gallons) per year] is for agriculture. The aquifer is the source of all water used at the INEL. Site activities withdraw water at an average rate of 7.4 million cubic meters (1.9 billion gallons) per year (DOE-ID 1993e). However, the baseline annual withdrawal rate dropped to 6.5 million cubic meters (1.7 billion gallons) in 1995. The average annual withdrawal is equal to approximately 0.4 percent of the water consumed from the Eastern Snake River Plain Aquifer, or 53 percent of the maximum annual yield of a typical irrigation well. Of the quantity of water pumped from the aquifer, a substantial portion is discharged to the surface or subsurface and eventually returned to it (DOE-ID l993d,e).

A sole-source aquifer, as designated by the Safe Drinking Water Act (SDWA 1974) is one that supplies 50 percent of the drinking water consumed in the area overlying the aquifer. Sole-source aquifer areas have no alternative source or combination of sources that could physically, legally, and economically supply all those who obtain their drinking water from the aquifer. Because groundwater supplies 100 percent of the drinking water consumed within the Eastern Snake River Plain (Gaia Northwest 1988) and an alternative drinking water source or combination of sources is not available, the Environmental Protection Agency designated the Snake River Plain Aquifer a sole-source aquifer in 1991 (FR 1991b).

DOE holds a Federal Reserved Water Right for the INEL, which permits a water pumping capacity of 2.3 cubic meters (80 cubic feet) per second and a maximum water consumption of 43 million cubic meters (11.4 billion gallons) per year for drinking, process water, and noncontact cooling. Because it is a Federal Water Right, the site's priority on water rights dates back to the establishment of the INEL.

4.9 Ecological Resources

This section describes the biotic resources - flora, fauna, threatened and endangered species, and wetlands - on the INEL site, which are typical of the Great Basin and Columbia Plateau. Because the proposed actions are most likely to affect areas near existing major facilities, this section emphasizes the biotic resources in those areas. However, because the proposed actions could affect other resources outside such areas (e.g., more mobile species like pronghorn, Antilocapra americana), it also describes biotic resources for the entire INEL site.

4.9.1 Flora

Vegetation on the INEL site is primarily of the shrub-steppe type and is a small fraction of the 45,000 square kilometers (111.2 million acres) of this vegetation type in the Intermountain West. The 15 vegetation associations on the INEL site range from primarily shadscale-steppe vegetation at lower altitudes through sagebrush- and grass-dominated communities to juniper woodlands along the foothills of the nearby mountains and buttes (Rope et al. 1993; Kramber et al. 1992; Anderson 1991). These associations can be grouped into six basic types: juniper woodland, grassland, shrub-steppe (which consists of "sagebrush-steppe" and "salt desert shrubs"), lava, bareground-disturbed, and wetland vegetation. Shrub-steppe vegetation, which is dominated by big sagebrush (Artemisia tridentata), saltbush (Atriplex spp.), and rabbitbrush (Chrysothamnus spp.) covers more than 90 percent of the INEL. Grasses include cheatgrass (Bromus tectorum), Indian ricegrass (Oryzopsis hymenoides), wheatgrasses, (Agropyron spp.), and squirreltail (Sitanion hysterix). Herbaceous plants include phlox (Phlox spp.), wild onion (Allium spp.), milkvetch (Astragalus spp.), Russian thistle (Salsola kali), and various mustards. Work being conducted by Idaho State University will provide additional information on INEL plant communities and the status of sensitive plant species.

Facility and human-disturbed (grazing not included) areas cover only about 2 percent of the INEL. Introduced annuals, including Russian thistle and cheatgrass, frequently dominate disturbed areas. These species usually are less desirable to wildlife as food and cover, and compete with more desirable perennial native species. These disturbed areas serve as a seed source, increasing the potential for the establishment of Russian thistle and cheatgrass in surrounding less-disturbed areas.
Vegetation inside facility boundaries is generally disturbed or landscaped. Species richness on the INEL is comparable to that of like-sized areas with similar terrain in other parts of the Intermountain West. Plant diversity is typically lower in disturbed and modified areas.

4.9.2 Fauna

The INEL site supports animal communities characteristic of shrub-steppe vegetation and habitats. More than 270 vertebrate species occur, including 46 mammal, 204 bird, 10 reptile, 2 amphibian, and 9 fish species (Arthur et al. 1984; Reynolds et al. 1986). Common small-mammal genera include mice (Reithrodontomys spp. and Peromyscus spp.), chipmunks (Tamias spp.), jackrabbits (Lepus spp.), and cottontails (Sylvilagus spp.).

Songbirds and passerines commonly observed at the INEL include the American robin (Turdus migratorius), horned lark (Eremophila alpestris), black-billed magpie (Pica pica), sage thrasher (Oreoscoptes montanus), Brewer's sparrow (Spizella breweri), sage sparrow (S. belli), and western meadowlark (Sturnella neglecta), while resident upland gamebirds include the sage grouse (Centrocercus urophasianus), chukar (Alectoris chukar), and grey partridge (Perdix perdix). Common migratory bird species, which use the INEL for part of the year, include a variety of waterfowl [e.g., mallard (Anas platyrhynchos), northern pintail (Anas acuta), and Canada goose (Branta canadensis)] and raptors [e.g., Swainson's hawk (Buteo swainsoni), rough-legged hawk (B. lagopus), and American kestrel (Falco sparverius)].

The most abundant big-game species that occurs on the INEL is the pronghorn, but mule deer (Odocoileus hermonius), moose (Alces alces), and elk (Cervus elaphus) are present in small numbers as transients. Other large mammals observed on the INEL include the coyote (Canis latrans), which is common across the site, and the badger (Taxidea taxus) and bobcat (Felis rufus), both of which are present across the site but are much less abundant. Fish, including kokanee salmon (Oncorhynchos nerka), rainbow trout (Oncorhynchos mykiss), and mountain whitefish (Prosopium williamsoni), occur on the INEL only when the Big Lost River flows onto the site (as a result of heavy rain- or snowfall in the mountains to the northwest); they are not full-time residents.

A number of researchers have studied effects of radiation exposure from contaminated areas at INEL on small mammals and birds, and have concluded that subtle sublethal effects (e.g., reduced growth rates and life expectancies) can occur in individual animals as a result of radiation exposure.
However, they can attribute no population or community-level impacts to such exposures (Halford and Markham 1978; Evenson 1981; Arthur et al. 1986; Millard et. al 1990).

The monitoring of radionuclide levels outside the boundaries of the various INEL facilities and off the INEL site has detected radionuclide concentrations above background levels in individual plants and animals (Markham 1974; Craig et al. 1979; Markham et al. 1982; Morris 1993), but these limited data suggest that populations of exposed animals (e.g., mice and rabbits) as well as animals that feed on these exposed animals (e.g., eagles and hawks) are not at risk.

4.9.3 Threatened, Endangered, and Sensitive Species

State and Federal regulatory agency lists (Lobdell 1992, 1995), the Idaho Department of Fish and Game Conservation Data Center list, and information from site surveys provided the information to identify Federal- and state-protected, candidate, and sensitive species that potentially occur on the INEL. This information identified two Federal endangered (bald eagle, and peregrine falcon) and nine Federal Category 2 candidate (white-faced ibis, northern goshawk, ferruginous hawk, burrowing owl, long-eared myotis, small-footed myotis, pygmy rabbit, Townsend's western big-eared bat, and Idaho pointheaded grasshopper) species as animals that potentially occur on the INEL site (Table 4.9-1). Five animal species listed by the state as Species of Special Concern occur on the site. No frequent observations of the Federal- or state-listed animal species have occurred near any of the facilities where proposed actions would occur. This analysis did not identify any Federal- or state-listed plant species as potentially occurring on the INEL site. Eight plant species identified by other Federal agencies and the Idaho Native Plant Society as sensitive, rare, or unique occur on the site (Chowlewa and Henderson 1984).

4.9.4 Wetlands

The U.S. Fish and Wildlife Service National Wetlands Inventory has identified more than 130 areas inside the boundaries of the INEL that might possess some wetlands characteristics. Surveys conducted in the fall of 1992 indicate that these possible wetlands cover about 1.4 percent (33 square kilometers or 8,206 acres) of the INEL site (Hampton et al. 1993). Approximately 70 percent of these possible wetlands areas occur near the Big Lost River and its spreading areas and playas, near the Birch Creek Playa, and in an area north of and in the general vicinity of Argonne National Laboratory-West. Limited riparian (riverbank) communities with mature trees along the Big Lost River (Reynolds 1993) reflect the intermittent flow in the river (1986 and 1993 were the last two years with flow reported on the site). The remainder of the possible wetlands are scattered throughout the INEL site. In 1994, INEL began evaluating these potential wetlands to determine if they meet the Corps of Engineers definition of jurisdictional wetlands (COE 1987). Approximately 20 wetlands are near facilities and are mostly manmade (e.g., industrial waste and sewage treatment ponds, borrow pits, and gravel pits).

Table 4.9-1. Threatened and endangered species, special species of concern, and sensitive species that may be found on the INEL.

	Name	Status[a]	Comments
BIRDS	Northern goshawk (Accipiter gentilis)	C2, SSC, FS, BLM	The ferruginous hawk nests on and migrates through the INEL. This species is found throughout the INEL but is observed more frequently in juniper woodlands. The peregrine falcon has been observed rarely in winter, but has not been observed during other seasons. The last sighting was in 1993 (Morris 1993). It is not known to nest on the INEL and is not commonly observed near facilities (Reynolds 1993a). The bald eagle is a winter resident and is locally common in the far north end and on the western edge of the INEL near Howe (Reynolds 1993a). It is not known to nest on the INEL and is not commonly observed near facilities (Reynolds 1993). The white-faced ibis, which uses aquatic and riparian habitats, is an uncommon migrant at the INEL. The
	Burrowing owl (Athene cunicularia)	C2, BLM	
	Ferruginous hawk (Buteo regalis)	C2, SSC, BLM	
	Swainson's hawk (Buteo swainsoni)	BLM	
	Great egret (Casmerodius albus)	SSC	
	Merlin (Falco columbarius)	SSC, BLM	
	Peregrine falcon (Falco peregrinus)	E	
	Gyrfalcon (Falco rusticolus)	BLM	
	Common loon (Gavia immer)	SSC, FS	
	Bald eagle (Haliaeetus leucocephalus)	E	
	Long-billed curlew (Numenius americanus)	SPS, BLM	
	American white pelican (Pelecanus erythrorhynchos)	SSC	

			long-billed curlew is known to nest on the north end of
	White-faced ibis (Plegadis chihi)	C2	the INEL near agricultural lands. The northern goshawk is a casual migrant through the INEL.
MAMMALS	Merriam's shrew (Sorex merriami)	SPS	The pygmy rabbit is common on the INEL, but its distribution is
	Pygmy rabbit (Brachylagus (Sylvilagus) idahoensis)	C2, BLM, SSC	patchy (Reynolds et al. 1986). Roosts and hibernation caves for
	California myotis (Myotis californicus)	SSC	Townsend's western big-eared bat occur on the INEL. All are over
	Fringed myotis (Myotis thysanodes)	SSC	7 kilometers (3 miles) from facilities. Brood caves might exist on the
	Western pipistrelle (Pipistrellus hesperus)	SSC, BLM	site but have not been located.
	Townsend's western big-eared bat (Plecotus townsendii)	C2, SSC, FS, BLM	
	Long-eared myotis (Myotis evotis)	C2	
	Small-footed myotis (Myotis subulatus)	CS	
PLANTS	Lemhi milkvetch (Astragalus aquilonius)	BLM, FS, INPS	The 8 plant species identified as sensitive, rare, or unique that are
	Painted milkvetch (Astragalus ceramicus var. apus)	3c, INPS-M	known to occur on the INEL occur primarily at a distance from INEL
	Winged-seed evening primrose (Camissonia pterosperma)	BLM, INPS-S	facilities and are uncommon on the INEL because they require unique
	Nipple cactus (Coryphantha missouriensis)	INPS-M	microhabitat conditions.
	Spreading gilia (Ipomopsis (Gilia) polycladon)	BLM, INPS-2	
	King's bladderpod (Lesquerella kingii var. cobrensis)	INPS-M	
	Tree-like oxytheca (Oxytheca dendroidea)	INPS-S	
	Sepal-tooth dodder (Cuscuta denticulata)	INPS-1	
INSECTS	Idaho pointheaded grasshopper (Acrolophitus pulchellus)	C2, BLM	Occurs just north of the INEL.

a. Key: C2 = Federal Category 2 species. BLM = Bureau of Land Management monitored. INPS-S = Idaho Native Plant Society sensitive.
3c = No longer considered for Federal listing. FS = U.S. Forest Service monitored. INPS-M = Idaho Native Plant.
E = Federal and state endangered species. INEL = Idaho National Engineering Laboratory. INPS-1 = Idaho Native Plant Society State Priority 1.
SSC= State species of special concern. SPS = State protected species. INPS-2 = Idaho Native Plant Society State Priority 2.

4.10 Noise

The major noise sources at the INEL occur primarily in developed operational areas. These sources include facilities; equipment and machines (e.g., cooling towers, transformers, engines, pumps, boilers, steam vents, paging systems, construction equipment, and materials-handling equipment); aircraft; and bus, car, truck, and railroad traffic. At the INEL boundary, which is more than 3 kilometers (2 miles) from any facility, noise from most sources is barely distinguishable from background noise levels. Some disturbance of wildlife activities could occur at the INEL as a result of noise from operational and construction activities. The State of Idaho and the counties in which the INEL is located have not established any regulations that specify acceptable community noise levels, with the exception of prohibitions on nuisance noise.

Existing INEL-related noises of public significance are from the transportation of people and materials to and from the site and in-town facilities via buses, trucks, private vehicles, helicopters, and freight trains. During the normal workweek, most of the 4,000 to 5,000 employees who work on the site (as opposed to those working in Idaho Falls) travel daily by buses from surrounding communities (see Section 4.3). In addition, 300 to 500 private vehicles travel to the INEL site from surrounding communities each day (see Section 4.11). Noise measurements along U.S. Highway 20 about 15 meters (50 feet) from the roadway indicate that the sound level from traffic ranges from 64 to 86 decibels, A-weighted (dBA) (Abbott et al. 1990), and that the primary source is buses (71 to 81 dBA). While few people reside within 15 meters (50 feet) of the roadway, the results indicate that INEL traffic noise might be objectionable to members of the public residing near principal highways or busy bus routes. The acoustic environment along the INEL site boundary in rural areas and at nearby areas away from traffic noise is typical of a rural location, with the day-night sound level (DNL) in the range of 35 to 50 dBA (EPA 1974).

Public exposure to aircraft noise is due in part to INEL-related activities. Air cargo and business travel of INEL personnel via commercial air transport is a significant fraction of all such travel in and out of regional airports. Onsite INEL security patrol and surveillance flights do not adversely affect individuals off the site because of the INEL's remoteness. For INEL helicopter flights that originate or terminate in Idaho Falls, members of the public are exposed to the unique noises produced by these aircraft. Because the number of flights per day is limited and most flights occur during nonsleeping hours, public exposure to aircraft nuisance noise is not great.

Normally only one train per day serves the INEL, via the Scoville spur. Noise sources related to rail transport include those from diesel engines, wheel-track contact, and whistle warnings at rail crossings. Even with only one or two exposures to these sources per day, individuals residing near the railroad tracks might find the noises mildly objectionable.

4.11 Traffic and Transportation

Roads are the primary access to and from the INEL site. Commercial shipments are transported via truck and plane, some bulk materials are transported via rail, and waste is transported by road and rail. This section discusses the existing traffic volumes, transportation routes, transportation accidents, and waste and materials transportation, including baseline radiological exposures from waste and materials transportation. This section summarizes the information in Lehto (1993).

4.11.1 Roadways

4.11.1.1 Infrastructure Regional and Site Systems. Figure 4.11 - 1 shows the existing

regional highway system. Two interstate highways serve the regional area. Interstate 15 (1-15), a north-south route that connects several cities along the Snake River, is approximately 40 kilometers (25 miles) east of the INEL site. 1-86 intersects 1-15 approximately 64 kilometers (40 miles) south of the INEL site, and provides a primary linkage from I-li to points west. 1-15 and US 91 are the primary access routes to the Shoshone-Bannock reservation. US 20 and US 26 are the main access routes to the southern portion of the INEL site. Idaho State Routes 22, 28, and 33 pass through the northern portion of the INEL; State Route 33 provides access to the northern INEL site facilities.

Table 4.11-1 lists the baseline (1991) traffic for several of these access routes. The level of service of these segments is currently designated "free flow," which is defined as "operation of vehicles is virtually unaffected by the presence of other vehicles."

The INEL has developed an onsite road system of approximately 140 kilometers (87 miles) of paved surface, including about 29 kilometers (18 miles) of service roads that are closed to the public.

Most of the roads are adequate for the current level of normal transportation activity and could handle some increased traffic volume. DOE plans to reconstruct several deteriorating INEL roads built in the 1950s that have been and will continue to be used to transport heavier-than-normal loads.

4.11.1.2 Infrastructure Idaho Falls. Approximately 4,000 DOE and contractor personnel

administer and support INEL work at offices in Idaho Falls. DOE shuttle vans provide hourly transport between in-town facilities. One of the busiest intersections is Science Center Drive and Fremont Avenue, which serves Willow Creek Building, Engineering Research Office Building, INEL Electronic Technology Center, and DOE Office Buildings. This intersection is congested during peak

Figure 4.11-1. Transportation routes in the vicinity of the INEL. (not available in electronic copy).

Table 4.11-1. Baseline traffic for selected highway segments.

weekday hours, but it is designed for the current traffic.

4.11.1.3 Transit Modes. Four major modes of transit use the regional highways, community

streets, and INEL site roads to transport people and commodities: DOE buses and shunle vans, DOE motor pool vehicles, commercial trucks, and personal vehicles. Table 4.11-2 summarizes the baseline miles for INEL-related traffic.

Table 4.11-2. Baseline annual vehicle miles traveled for Idaho National Engineering Laboratory-related traffic. a

4.11.2 Railroads

Figure 4.11-1 shows the Union Pacific Railroad lines in southeastern Idaho. Idaho Falls receives railroad freight service from Butte, Montana, to the north, and from Pocatello and Salt Lake City to the south, The Union Pacific Railroad's Blackfoot-to-Arco branch, which crosses the southern portion of the INEL, provides rail service to the site for the shipment of spent nuclear fuel and other waste, bulk commodities, and radioactive materials. This branch connects with a DOE-owned spur line at Scoville Siding, then links with developed INEL areas. Table 4.11-3 lists rail shipments for Fiscal Years 1988 through 1992.

Table 4.11-3. Loaded rail shipments to and from the Idaho National Engineering Laboratory (1988-1992)a.

4.11.3 Airports and Air Traffic

Commercial airlines provide Idaho Falls with jet aircraft passenger and cargo service, as well as commuter service to both the Idaho Falls and Pocatello airports. In addition, local charter service is available in Idaho Falls, and private aircraft use the major airport and many other fields in the area. Total landings at the Idaho Falls airport for 1991 and 1992 were 5,367 and 5,598, respectively. The Idaho Falls and Pocatello airports collectively record nearly 7,500 landings annually.

Non-DOE air traffic over the INEL site is limited to altitudes greater than 305 meters (1,000 feet) over buildings and populated areas, and non-DOE aircraft are not permitted to use the site. The primary air traffic at the INEL site is DOE helicopters, which are used for security and emergency purposes. These helicopters have specific operations stations and duties.

4.11.4 Accidents

From 1987 through 1992, the average motor vehicle accident rate was 0.94 accident per million kilometers (1.5 accidents per million miles) for INEL vehicles, which compares with an accident rate of 1.5 accidents per million kilometers (2.4 accidents per million miles) for all DOE complex vehicles and 8 accidents per million kilometers (12.8 accidents per million miles) nationwide for all motor vehicles (Lehto 1993). There are no recorded rail or air accidents associated with the INEL and, to date, no fatal air traffic accidents have involved flights through either the Idaho Falls or Pocatello airports.

4.11.5 Transportation of Waste, Materials, and Spent Nuclear Fuel

Hazardous, radioactive, industrial commercial, and recyclable wastes are transported oYl the INEL site. Federal and State regulations and requirements govern the transportation of hazardous and radioactive materials (Lehto 1993). Hazardous materials include commercial chemical products and hazardous wastes that are nonradioactive; they are regulated and controlled based on their chemical toxicity. Onsite spent nuclear fuel comes from Argonne National Laboratory - West, the Naval Reactors Facility, and the Advanced Test Reactor; it is transported by truck to various onsite storage and research and development facilities.

This assessment used six years of data (1987 through 1992) to establish a baseline of radiological doses from incident-free, onsite total nonnaval spent nuclear fuel transportation at the INEL. **Table 4.11-4 lists the results in terms of cumulative doses (1995-2035) and health effects.** These doses do not include onsite naval shipments, which are assessed in Attachment A to Appendix D of Volume 1 of this ElS. The baseline includes no offsite shipments, which are addressed in Appendixes D and I.

Table 4.11-4. Cumulative dose and cancer fatalities from incident-free onsite shipment of nonnaval spent nuclear fuel at the Idaho National Engineering Laboratory for 1995 through 2035. (a,b)

4.12 Occupational and Public Health and Safety

4.12.1 Radiological Health and Safety

DOE Order 5480.11, "Radiation Protection for Occupational Workers" (DOE 1992b), limits the radiation dose that INEL workers can receive to 5 rem per year; administrative controls further limit a worker dose to 2 rem per year, except under unusual circumstances. In addition, DOE has established a comprehensive program, known as ALARA (As Low As Reasonably Achievable), to ensure the reduction of occupational doses to the extent practicable.

The largest fraction of the occupational dose received by INEL workers is from external radiation. Internal radiation doses constitute a small fraction of the occupational dose. Personnel who could receive annual external radiation exposures with measured doses greater than 0.1 rem receive a thermoluminescent dosimeter that they must wear at all times during work on the site. DOE used recorded doses for 1987 to 1991 as a baseline for routine site operations for this EIS. During this period, the INEL monitored about 6,000 workers annually for radiation exposure. About 32 percent of those individuals received measurable radiation doses. Monitoring reports indicate that, from 1987 to 1991, 20 individuals (most of whom were maintenance and construction workers employed by M-K Ferguson at the Idaho Chemical Processing Plant) received annual doses larger than 2 rem (4 individuals in 1987, 1 in 1989, and 15 in 1990).

From 1987 to 1991, the average occupational dose to individuals who had received measurable doses was 0.156 rem per year, resulting in an average collective dose (the number of monitored workers receiving measurable doses was about 32 percent or 1,920) of about 300 person-rem. The resulting number of expected excess latent cancer fatalities would be less than 1 for each year of operation.

This analysis based the doses to the maximally exposed individual and offsite population on baseline radioactive concentrations associated with normal operations. The baseline dose to the maximally exposed individual is 5.6 y 10-2 millirem, which corresponds to a latent fatal cancer probability of 2.8 y 10-8. The baseline population dose is 7.0 y 10-2 person-rem which, corresponds to a latent fatal cancer incidence of less than 1 (4 y 10-5) annually and less than 1 (1 y 10-3) over 40 years.

4.12.2 Nonradiological Exposure and Health Effects

DOE used the air quality data in Table 4.7-2 to evaluate health impacts associated with potential exposure to two compound classes: criteria pollutant and toxic. This analysis has based health effects on air emissions only, and not water pathways, because none of the alternatives would involve the discharge of pollutants to surface waters or the subsurface. Table 4.7-2 lists 5 criteria pollutant and 26 toxic compounds. The classification of two of the toxic compounds (benzene and formaldehyde) as carcinogens was consistent with EPA designations published in the Integrated Risk Information System (IRIS) data base (DOE 1991b). However, this data base does not include sufficient data to perform a quantitative inhalation cancer risk assessment.

To obtain a hazard index, this analysis evaluated toxic and criteria pollutant compound health effects by adding hazard quotients for each compound. The EPA Risk Assessment Guidance for Superfund (EPA 1989) describes this approach. The hazard quotient is the ratio of compound concentration or dose to a Reference Concentration (RfC) or Dose (RfD). For compounds without listed Reference Concentration or Dose values, the analysis used appropriate State of Idaho standards.

The use of the noncancer hazard index assumes a level of exposure (standard) below which adverse health effects would be unlikely. The hazard index is not a statistical probability; therefore, it cannot be interpreted as such.

This analysis based toxic and criteria pollutant compound hazard index values for the maximally exposed individual on the maximum concentrations for the compounds at the INEL site boundary, public access roads inside the INEL site boundary, and the Craters of the Moon Wilderness Area. Because the hazard index for criteria pollutants is less than 1, no adverse health effects would be likely from routine operations for either workers or the maximally exposed individual. Because the hazard index for toxic pollutants exceeds 1, the potential for carcinogenic health risks could exist. However, varying spacial and temporal distributions of the concentrations of individual air pollutants make it unlikely that any individual would be exposed to all the pollutants all the time. Since individual hazard indices for the toxic compounds are less than 1, adverse health effects are not expected.

4.12.3 Occupational Health and Safety

Total injury and illness incidence rates at the INEL varied from an annual average of 1.8 to 4.9 per 200,000 work hours from 1987 to 1991. During this time, total lost workday cases ranged from a low of 1 per 200,000 work hours in 1988 and 1989 to a high of 2.6 per 200,000 work hours in 1991. The rates appear higher for 1991 because of a 1990 change in reporting requirements for injuries and illnesses. INEL rates for 1987 to 1989 are below overall DOE rates (2.9 total injury and illness incidence and 1.4 total lost workday cases per 200,000 work hours) and Bureau of Labor Statistics rates (8.5 total injury and illness incidence and 4.0 total lost workday cases per 200,000 work hours). For 1990 and 1991, INEL rates are slightly above overall DOE rates, but below Bureau of Labor Statistics rate.

There were 1,337 total recordable injury and illness cases at the INEL from 1987 to 1991, for an average of 8,385 employees working 79,654,000 hours. Of these cases, 114 (8.5 percent) were occupational illnesses, of which 48 percent were repeated trauma disorders and 30 percent were classified as skin diseases or disorders. One fatality occurred at the INEL between 1987 and 1991 when an employee was struck and killed by a forklift.

4.13 Idaho National Engineering Laboratory Services

This section discusses water, electricity, fuel capacities and consumption, wastewater disposal, and security and emergency protection at INEL facilities.

4.13.1 Water Consumption

A system of about 30 wells, with pumps and storage tanks, provides the water supply for the INEL site. Because of the distance between site facility areas, the water supply system for each facility is independent. The site uses no natural surface water. The City of Idaho Falls water supply system, which includes about 16 wells, provides water to DOE and contractor facilities in the city.

A Water Rights Agreement between DOE and the State of Idaho regulates groundwater use at the INEL site. Under this agreement, INEL has claim to 2,300 liters per second (36,000 gallons per minute) of groundwater, not to exceed 43 billion liters (11 billion gallons) per year (Teel 1993). DOE has not measured the total pumping rate from the aquifer, which would depend on the number of pumps operating. There is a slight possibility that the site could exceed the regulated pumping rate for very short periods, such as during recovery from an extended power outage when many pumps would run to refill depleted storage tanks.

The average INEL site water consumption from 1987 through 1991 was 7.4 billion liters (1.9 billion gallons) per year, based on the cumulative volumes of water withdrawn from the wells (Teel 1993). The projected baseline usage for 1995 will be about 6.5 billion liters (1.7 billion gallons). The estimated average water consumption of Idaho Falls facilities is 300 million liters (80 million gallons) per year.

4.13.2 Electricity Consumption

The Antelope substation supplies commercial electric power to the INEL site through two feeders to the Federally owned Scoville substation. The Scoville substation supplies electric power directly to the INEL electric power distribution system (Teel 1993). The contract with Idaho Power Company to supply electric power to the INEL site provides "up to 45,000 kilowatts monthly" at 13.8 kilovolts (IPC/DOE 1986). Hydroelectric generators along the Snake River in southern Idaho and the Bridger and Valmy coal-fired thermal electric generation plants in southwestern Wyoming and northern Nevada, respectively, generate the electric power supplied by Idaho Power. The Experimental Breeder Reactor-II can also provide approximately 12 to 15 megavolt-amperes of capacity for the electric power loop (Teel 1993).

The rated capacity of the INEL site power transmission loop line is 124 megavolt-amperes. The peak demand on the system from 1990 through 1993 was about 40 megavolt-amperes, and the average usage was slightly less than 217,000 megawatt-hours per year (Teel 1993). This usage rate should decrease by about 4 percent by 1995.

The INEL facilities in Idaho Falls receive electric power from the City of Idaho Falls, which operates four hydroelectric power generation plants on the Snake River along with substation and distribution facilities. The Bonneville Power Administration, which operates hydroelectric plants on the Columbia River system, supplies supplemental power to the City of Idaho Falls. In 1993, Idaho Falls facilities used 31,500 megawatt-hours of electricity (Teel 1993).

4.13.3 Fuel Consumption

Fuels consumed at the INEL site include several liquid petroleum fuels, coal, and propane. All fuels are transported to the site for storage and use. Natural gas is the only reported fuel consumed at the INEL Idaho Falls facilities; the Intermountain Gas Company provides this fuel through a system of underground lines (Teel 1993).

The average annual fuel consumption at the INEL site from 1990 through 1993 was as follows: fuel oil, 10,578,000 liters (2,795,000 gallons); diesel fuel, 5,690,000 liters (1,500,000 gallons); and propane gas, 568,000 liters (150,000 gallons). The INEL also uses about 8,200 metric tons (9,000 tons) of coal. Fuel storage is provided at each facility and inventories are restocked as necessary. No fossil fuel shortage has ever occurred at the INEL site (Teel 1993).

4.13.4 Wastewater Disposal

Sanitary wastewater systems at the smaller onsite facility areas consist primarily of septic tanks and drain fields. The larger areas, such as Central Facilities Area, Idaho Chemical Processing Plant, and Test Reactor Area, have wastewater treatment facilities. The City of Idaho Falls wastewater treatment system serves the Idaho Falls facilities (Teel 1993).

The average annual wastewater discharge volume at the INEL site from 1989 through 1991 was 537 million liters (142 million gallons). The wastewater from DOE and contractor-operated facilities

in Idaho Falls is not metered but is estimated to be 300 million liters (80 million gallons) per year.
The primary causes of the difference between water pumped and estimated wastewater discharge are evaporation from ponds and cooling towers, irrigation of landscaped areas, and discharge of unmetered wastewater (Teel 1993). Some industrial wastewater, such as steam condensate, is also discharged to evaporation ponds and injection wells.

4.13.5 Security and Emergency Protection

This section describes the fire protection and prevention, security, and emergency preparedness resources for the INEL site and the surrounding areas. This discussion includes the INEL Fire Department, DOE and INEL Emergency Preparedness, and DOE and INEL Security. DOE established an Emergency Management System that incorporates all applicable requirements for emergency planning, preparedness, and response at the INEL. Each INEL facility must prepare an Emergency Plan that contains detailed contingency plans and emergency procedures.

4.13.5.1 DOE Fire Department. The contractor-operated Fire Department staffs and operates

three fire stations on the INEL that support the entire site. Each station has the equipment and expertise to respond to explosions, fires, spills, and medical emergencies. These stations are on the north end at Test Area North, at Argonne National Laboratory-West, and at the Central Facilities Area.
Each station has a minimum of one engine company capable of supporting any fire emergency in its assigned area. The Fire Department has a staff of 44 firefighters and 11 support personnel and operates with a minimum critical staff of 7 firefighters at any time. In addition to providing firefighting services, the Fire Department provides the INEL ambulance, emergency medical technician (EMT), and hazardous material response services. The Fire Department has mutual aid agreements with other firefighting organizations, such as the Bureau of Land Management and the Cities of Idaho Falls, Blackfoot, and Arco. Through these agreements, the Idaho Falls Fire Department serves DOE facilities in the City of Idaho Falls.

4.13.5.2 DOE and INEL Emergency Preparedness. Each DOE INEL contractor

administers and staffs its own emergency preparedness program under the direction and supervision of DOE. All contractor programs for emergency control and response are compatible. The Warning Communication Center is in the DOE Headquarters building and staffed by the INEL prime contractor with DOE oversight; it is the communication and overall control center for support to onscene commanders in charge of an emergency response. The DOE emergency preparedness system includes mutual aid agreements with all regional county and major city fire departments, police, and medical facilities. Through the agreements, the Idaho Falls emergency preparedness organizations serve DOE facilities in the City of Idaho Falls.

4.13.5.3 DOE and INEL Security. DOE has oversight responsibility for safeguards and

security at the INEL. The security program has three categories: security operations, personnel security, and safeguards. The security operations division provides asset protection (classified matter, special nuclear material, facilities, and personnel) and technical security (computer and information).
Under this category, DOE administers the INEL protective force, which is supplied by contract. The personnel security staff processes personnel security clearances. The safeguards department is responsible for the management and accountability of special nuclear materials. The INEL protective force, consisting of 200 armed guards and 350 support personnel, provides the onsite personnel who administer the programs. Each INEL contractor has a safeguards and security staff, divided in a similar manner, to manage the security associated with its facilities. Contractor safeguards and security staffs range from about 5 to 60 persons, depending on the size and complexity of the

associated facilities. Each staff works with the INEL protective forces.

4.14 Materials and Waste Management

This section summarizes the management of materials and wastes (high-level, transuranic, mixed low-level, low-level, hazardous, industrial and commercial solid wastes and hazardous materials) at the INEL and Idaho Falls facilities, and presents an overview of the current status of the various waste types generated, stored, and disposed at the INEL.

The total amount of waste generated and disposed has been reduced through waste minimization and treatment. The INEL attains waste minimization by reducing or eliminating waste generation, by recycling, and by reducing the volume, toxicity, or mobility of waste before storage or disposal. In addition, the site has achieved volume reduction of radioactive wastes through more intensive surveying, waste segregation, and use of administrative and engineering controls.

The quantitative data presented in this section are from Volume 2 of this EIS, unless otherwise noted.

4.14.1 High-Level Waste

At present, about 11,900 cubic meters (4,970 cubic yards calcine solid and 2,140,000 gallons liquid) of high-level waste are in storage at the INEL Idaho Chemical Processing Plant (see Figure 2-1 for locations of major waste management facilities). This facility blends liquid waste, consisting of aluminum and zirconium wastes from past spent nuclear fuel reprocessing, and sodium-bearing wastes, and processes them through calcination to produce a granular calcine solid. Because of the termination of reprocessing, the site no longer generates liquid high-level waste, with the exception of high-level waste residues. Liquid high-level wastes generated by prior reprocessing activities are solidified at the site. At present, the site generates liquid waste that is not directly the result of reprocessing. The site manages this liquid as high-level waste. The site will calcine the liquid high-level waste that does not contain sodium, and as much sodium-bearing high-level waste as practicable by January 1, 1998, in accordance with the Amended Order Modifying Order of June 28, 1993, United States District Court for the District of Idaho, December 22, 1993. The projected 1995 baseline for high-level waste generation is 750 cubic meters (980 cubic yards) annually (EG&G 1993).

4.14.2 Transuranic Waste

About 65,000 cubic meters (85,000 cubic yards) of transuranic and alpha-contaminated low-level wastes are retrievably stored and 62,000 cubic meters (81,000 cubic yards) of transuranic waste (Morton and Hendrickson 1995) have been buried at the Radioactive Waste Management Complex at the INEL. At present, no facilities can dispose of transuranic waste; however, DOE ultimately intends to retrieve, repackage, certify, and ship stored transuranic wastes at the INEL to a potential Federal repository for final disposition. DOE has not determined the disposition of alpha-contaminated low-level waste and buried waste. Since the October 1988 ban by the State of Idaho prohibiting shipments of transuranic waste to the INEL, DOE has shipped only minor amounts of transuranic waste generated on the site to the INEL Radioactive Waste Management Complex for interim storage. At present, there are no treatment facilities for transuranic wastes at the INEL. The projected 1995 baseline for transuranic waste generation is 6 cubic meters (8 cubic yards) annually (EG&G 1993).

4.14.3 Mixed Low-Level Waste

At present, DOE accepts only mixed low-level waste generated at the INEL for treatment and disposal at the INEL. DOE stores mixed low-level waste generated at the INEL at interim storage facilities until treatment systems become available or operational. A total of 1,800 cubic meters (2,400 cubic yards) of mixed low-level waste interim storage capacity is available at the INEL. Current mixed low-level waste interim storage is approximately 1,100 cubic meters (1,400 cubic yards). Treatment technologies exist for much of the mixed low-level waste generated at the INEL, and waste minimization eliminates potential sources of mixed low-level waste before generation. The projected 1995 baseline for mixed low-level waste is 525 cubic meters (687 cubic yards) annually (EG&G 1993).

4.14.4 Low-Level Waste

Through 1991, DOE disposed of 145,000 cubic meters (190,000 cubic yards) of low-level waste at the Radioactive Waste Management Complex. In 1991, the total available low-level waste disposal capacity at the complex was 37,000 cubic meters (48,000 cubic yards). DOE has curtailed low-level waste treatment since 1991 while waiting for updated safety documentation and an environmental impact assessment for the Waste Experimental Reduction Facility. The INEL stores low-level waste awaiting treatment on asphalt or concrete pads at the Waste Experimental Reduction Facility and in radioactive waste storage containers at the generating facilities. The projected 1995 baseline for low-level waste generation is 4,270 cubic meters (5,585 cubic yards) annually (EG&G 1993).

4.14.5 Hazardous Waste

DOE collects hazardous waste generated at the INEL and stores it temporarily at the Hazardous Waste Storage Facility before shipping it off the site. The Hazardous Waste Storage Facility has adequate storage capacity [approximately 64 cubic meters (84 cubic yards)] to manage the quantities of hazardous waste generated at the INEL. The site recycles, reuses, or reprocesses such waste if possible, and might replace some hazardous substances with nonhazardous substances.

4.14.6 Industrial/Commercial Solid Waste

DOE disposes of the industrial and commercial solid waste generated at the site in the INEL Landfill Complex at the Central Facilities Area. The Landfill Complex has approximately 910,000 square meters (225 acres) of land available for solid waste disposal, including the remaining area at Landfill III, which is currently in use. The estimated capacity of the INEL Landfill Complex will be sufficient to dispose of INEL waste for 30 to 50 years; however, capacity of the current excavations will be filled by 1998. DOE has proposed expanding the excavation. Volume 2 of this EIS describes the landfill expansion project. The industrial and commercial solid waste landfill currently in use is in a 48,000-square-meter (12-acre) gravel pit area north of Disposal Area II. DOE does not expect to store solid waste intended for disposal. Waste segregation occurs at each INEL facility so recyclable materials do not enter the solid waste stream. The average annual volume of waste disposed at the Central Facilities Area landfill from 1988 through 1992 was approximately 52,000 cubic meters (68,000 cubic yards) (also the projected 1995 baseline) (EG&G 1993).

4.14.7 Hazardous Materials

The INEL 1993 chemical inventory lists 774 hazardous chemicals. The number and the total weight of hazardous chemicals used on the site and at individual facilities change daily in response to use. The annual Superfund Amendments and Reauthorization Act reports for the INEL facilities include year-to-year inventories.

5. ENVIRONMENTAL CONSEQUENCES

5.1 Overview

This chapter discusses the potential environmental consequences for each spent nuclear fuel management alternative described in Chapter 3. The U.S. Department of Energy (DOE) used the environmental consequence analyses of nonnaval spent nuclear fuel management from Volume 2 as input for this chapter; however, DOE made necessary adjustments to accommodate the differences between Volume 1 and Volume 2 alternatives. In addition, DOE adjusted the 10-year planning horizon for Volume 2 alternatives to 40 years for Volume 1.

As described in Chapter 1, this chapter analyzes only nonnaval DOE actions; however, Section 5.16, "Cumulative Impacts and Impacts from Connected or Similar Actions," includes impacts from the Naval Nuclear Propulsion Program and nonnaval DOE impacts that are cumulative. The Appendix B restriction of analysis to nonnaval actions results in Alternative 2 (options 2a, 2b, and 2c) becoming a single alternative.

Chapter 5 addresses potential impacts from construction and normal operations for each element of the affected environment described in Chapter 4. In addition, it provides potential consequences from accidents and several types of summary information. In cases where the consequence analysis does not result in a distinction among the alternatives, this chapter describes the consequences without division by alternative to avoid needless repetition. Tables 3-4 through 3-6 in Section 3.2 summarize and compare the potential impacts associated with each alternative.

5.2 Land Use

Alternatives 1, 2, 4b(2), and 5a [No Action, Decentralization, Regionalization by Geography (Elsewhere), and Centralization at other DOE sites] would have the least impact on land use, affecting 0.8 acre (0.003 square kilometer); Alternatives 4b(1) [Regionalization by Geography (INEL)] and 5b (Centralization at the INEL) would result in the greatest changes, impacting nearly 31 acres (0.12 square kilometer).

Overall environmental impacts on land use by any of the alternatives would be small because DOE would build new facilities in developed areas that it has already dedicated to industrial use and that previous activities have disturbed. Under all the alternatives, proposed activities would be consistent with the existing land use plans discussed in Section 4.2 and would be similar to uses in existing developed areas on the site. None of the proposed activities would involve land outside the INEL boundaries, and no effects on surrounding land uses or local land use plans should occur.

No onsite land use restrictions due to Native American treaty rights would exist for any of the alternatives described in this EIS. Potential impacts on Native American and other cultural resources are discussed in Section 5.4 (Cultural Resources) and in Appendix L (Environmental Justice).

5.3 Socioeconomics

This section describes the potential effects of the spent nuclear fuel alternatives on the socioeconomic resources of the region of influence described in Section 4.3. Tables 5.3-1 and 5.3-2 list proposed changes in the INEL-related workforce and population. Figure 5.3-1 shows these proposed changes.

5.3.1 Methodology

This section addresses socioeconomic impacts in terms of both direct and secondary employment and population effects. Direct effects are changes in INEL employment that DOE expects to occur under each alternative and include construction and operations phase impacts. Secondary effects include indirect and induced impacts. Indirect effects are impacts to regional businesses and employment resulting from changes in DOE regional purchases or nonpayroll expenditures. Induced effects are impacts to regional businesses and employment that result from changes in payroll spending by affected INEL employees. The total economic impact to the region is the sum of direct and secondary effects.

The bases for the estimated direct impacts in this section are project summary data that DOE developed in cooperation with INEL contractors. Employment impacts represent actual changes in INEL staffing; they do not include changes in staffing due to a reassignment of the existing INEL workforce. The projected decline in baseline INEL activity is not part of any alternative and therefore, a comprehensive analysis of potential impacts was not included. Projected declines in baseline site employment are presented in Figure 5.3-1 in order to provide the reader with a framework for evaluating potential employment and population impacts. This assessment used RIMS II to estimate total employment impacts with multipliers that the U.S. Bureau of Economic Analysis developed specifically for the INEL region of influence. A comprehensive discussion of the methodology is provided in Appendix F-1 of Volume 2. Cumulative impacts on socioeconomic resources in the region are discussed in Section 5.16.

Table 5.3-1. Estimated changes in employment and population for Alternatives 3, 4a, 4b(1) and 5b, 1995 - 2004.

Factor	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Direct employment	0	0	0	0	250	250	375	375	375	375
Secondary employment	0	0	0	0	352	352	528	528	528	528
Total employment change	0	0	0	0	602	602	903	903	903	903
Change in ROI[b] labor force (%)	0.0	0.0	0.0	0.0	0.5	0.5	0.8	0.8	0.8	0.7
Change in ROI employment (%)	0.0	0.0	0.0	0.0	0.6	0.6	0.8	0.8	0.8	0.8
Population change	0	0	0	0	2,027	2,027	3,040	3,040	3,040	3,040
Change in ROI population (%)	0.0	0.0	0.0	0.0	0.8	0.8	1.1	1.1	1.1	1.1

a. Sources: Johnson (1995); USBEA (1993); USBC (1992).
b. ROI = region of influence.

Table 5.3-2. Estimated changes in employment and population for Alternatives 4b(2) and 5a, 1995 - 2004.

Factor	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Direct employment	50	50	0	0	0	0	0	0	0	0
Secondary employment	70	70	0	0	0	0	0	0	0	0
Total employment change	120	120	0	0	0	0	0	0	0	0
Change in ROI[a] labor force (%)	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Change in ROI employment (%)	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Population change	405	405	0	0	0	0	0	0	0	0
Change in ROI population (%)	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

a. Sources: Johnson (1995); USBEA (1993); USBC (1992).
b. ROI = region of influence.

5.3.2 Alternatives 1 and 2 - No Action and Decentralization

Activities associated with Alternatives 1 and 2 would not result in any additional construction or operations jobs at the INEL; therefore, implementation of either of these alternatives would have no impact on socioeconomic resources in the region of influence.

5.3.3 Alternatives 3, 4a, 4b(1), and 5b - 1992/1993 Planning Basis, Regionalization by Fuel Type, Regionalization by Geography (INEL), and Centralization at the INEL

5.3.3.1 Construction. As listed in Table 5.3-1, construction employment under these alternatives would peak during the period from 2001 to 2004 with approximately 375 additional direct jobs per year. When added to the estimated 528 indirect jobs, the total employment impact in the region would be an addition of approximately 903 jobs. Employment would decline to zero by 2008.

Based on historic data, approximately 97 percent of the new employees who would fill these jobs would live in the seven-county region of influence. As listed in Table 5.3-1, if all new jobs (903) were filled by in-migrants to the region, there would be a 0.8-percent increase in the regional labor force and in regional employment during the peak years. These changes would be minimal and would have no adverse impacts on socioeconomic resources in the region. In fact, although the implementation of any of these alternatives would result in an increase over projected employment levels, as shown in Figure 5.3-1, there would be an overall decline in employment from projected 1995 levels.

Assuming each new employee represented one household and 3.47 persons per household, there would be a corresponding increase in regional population levels of 1.1 percent (approximately 3,000 people). Given this minor change in population, DOE expects potential impacts on the demand for community resources and services such as housing, schools, police, health care, and fire protection to be negligible.

5.3.3.2 Operations. Activities associated with Alternatives 3, 4a, 4b(1), and 5b would not

require any additional operations jobs at the INEL. Therefore, the implementation of either of these alternatives would have no impact on socioeconomic resources in the region of influence.

5.3.4 Alternatives 4b(2) and 5a - Regionalization by Geography (Elsewhere) and Centralization at Other

DOE Sites

5.3.4.1 Construction. As listed in Table 5.3-2, construction employment under these

alternatives would peak during the period from 1995 to 1996 with approximately 50 additional direct jobs per year. When added to the estimated 70 indirect jobs, the total employment impact in the region would be approximately 120 jobs. Employment after 1996 would drop to zero.

Figure 5.3-1. INEL employment by SNF alternative relative to site employment projections. (not available in electronic copy)

Based on historic data, approximately 97 percent of the new employees who would fill these jobs would live in the seven-county region of influence. As listed in Table 5.3-2, if all new jobs (120) were filled by in-migrants to the region, there would be a 0.1-percent increase in the regional labor force and in regional employment levels during the peak years. These changes would be minimal and would have no adverse impacts on socioeconomic resources in the region. In fact, although the implementation of any of these alternatives would be an increase over projected employment levels from 1995 to 1996, as shown in Figure 5.3-1, there would be an overall decline in employment from projected 1995 levels.

Assuming each new employee represented one household and 3.47 persons per household, there would be a corresponding increase in regional population levels of 0.2 percent (approximately 400 people). Given this minor change in population, DOE expects potential impacts on the demand for community resources and services such as housing, schools, police, health care, and fire protection to be negligible.

5.3.4.2 Operations. Activities associated with Alternatives 4b(2) and 5a would not result in

any additional operations jobs at the INEL. Therefore, the implementation of either of these alternatives would have no impact on socioeconomic resources in the region of influence.

5.4 Cultural Resources

This section summarizes the potential impacts of spent nuclear fuel management activities on cultural resources at the INEL site.

This assessment evaluated both direct and indirect impacts due to the proposed alternatives. At the INEL, direct impacts to archaeological resources usually would be those associated with ground disturbance from construction activities. Direct impacts to existing historic structures could result from demolition, modification, deterioration, isolation from or alteration of the character of the property's setting; or introduction of visual, audible, or atmospheric elements out of character or that alter the property's setting. In addition, indirect impacts to archaeological resources could occur due to an overall increase in activity at the INEL, which could bring a larger workforce closer to significant sites. Direct impacts to traditional resources could occur through land disturbance, vandalism, or changes to the environmental settings of traditional use and sacred areas. Impacts could result from pollution, noise, and contamination that could affect the traditional hunting and gathering areas or the visual or audible settings of sacred areas.

The potential for adverse impacts on cultural resources would be the least under Alternatives 1, 2, 4b(2), and 5a, which would disturb approximately 0.8 acres (0.003 square kilometer). Impacts would be minor because surveys of the area to be disturbed found no eligible cultural resources (Reed et al. 1986; DOE 1993a).

The potential for adverse impacts on cultural resources would be similar under Alternatives 3, 4a, 4b(1), and 5b with the greatest potential under Alternatives 4b(1) and 5b [Regionalization by Geography (INEL) and Centralization at the INEL], which would involve the disturbance of nearly 31 acres (0.12 square kilometer). Again, impacts would be minimal because surveys of the previously disturbed area found no eligible cultural resources (Reed et al. 1986). Under these alternatives, proposed modifications at the Idaho Chemical Processing Plant facilities could adversely affect historically significant structures and could require consultation with the Idaho State Historic Preservation Office (Braun et al. 1993).

The Shoshone-Bannock Tribes are also concerned with the potential impact to important Native American resources from changes in the visual setting, noise, air quality, or water quality. Because activities associated with spent nuclear fuel management would take place within existing facility areas currently engaged in similar activities, DOE does not expect any impacts to important Native American resources from alteration of the visual setting or noise associated with implementation of any of the alternatives. There could be temporary, minor impacts on air quality from fugitive dust associated with construction activities. Emissions of radionuclides to the air under normal operations would be minor and would be well below applicable standards and guidelines. Under normal operating conditions, radioactive discharges to the soil or directly to the aquifer would not occur.

DOE would minimize the potential for direct and indirect adverse impacts on traditional use resources from pollution, noise, and contamination through compliance with applicable local, state, and Federal laws and regulations. Impact avoidance and other mitigation measures for cultural resources are described in Section 5.20.2.

5.5 Aesthetic and Scenic Resources

None of the alternatives for spent nuclear fuel management at the INEL would have adverse consequences on scenic resources or aesthetics because DOE would confine the proposed projects to developed areas. Although the construction of the proposed facilities would produce fugitive dust that could temporarily affect visibility, the INEL would follow standard construction practices to minimize both erosion and dust generation. Facility operations under each alternative would not produce emissions to the atmosphere that would impact visibility.

5.6 Geology

This section discusses the potential effects of the spent nuclear fuel management alternatives on geologic resources at the INEL site.

Proposed INEL spent nuclear fuel management activities would only have minor localized impacts on the geology of the site for all the alternatives. Direct impacts to geologic resources at the site would be associated with the disturbance or extraction of surface deposits to construct new facilities. These impacts could include excavations into the soil and rock of the site, soil mounding and banking, and the extraction of aggregate materials from gravel and borrow pits on the site. Table 5.6-1 lists estimated extractions of aggregate from site gravel pits for all INEL spent nuclear **fuel, environmental restoration, and waste management projects.** These values serve to bound the spent nuclear fuel project usage.

A secondary impact to geological resources from construction activities would be the potential for increased soil erosion. DOE would minimize any potential soil erosion by the use of Best Management Practices designed to control stormwater runoff and slope stability.

Table 5.6-1. Estimated INEL gravel/borrow use (cubic meters). ,b

Alternative	Estimated Gravel/Borrow Use
1. No Action	158,000
2. Decentralization	158,000
3. 1992/1993 Planning Basis	392,000
4a. Regionalization by Fuel Type	392,000
4b(1) Regionalization by Geography (INEL)	1,772,000
4b(2) Regionalization by Geography (Elsewhere)	296,000
5a. Centralization at other DOE Sites	296,000
5b. Centralization at the INEL	1,772,000

a. Source: EG&G (1994).
b. To convert cubic meters to cubic yards, multiply by 1.31.

5.7 Air Quality and Related Consequences

This section describes the potential nonradiological and radiological impacts to air quality associated with each alternative. The term "baseline concentrations" is defined as the sum of the concentrations resulting from potential emissions from current operations and those resulting from planned upgrades or modifications that DOE would construct or operate prior to any of the proposed actions described in this EIS. Additional information is provided in Section 5.7 and Appendix F-3 of Volume 2.

5.7.1 Alternative 1 - No Action

5.7.1.1 Nonradiological Air Quality. Construction activities associated with this alternative

would be limited to upgrading an existing facility. Potential impacts to air quality from construction activities would include fugitive dust and exhaust emissions from support equipment. DOE assessed the impacts from construction using the EPA Fugitive Dust Model (FDM) (Winges 1992). The modeling results showed that the expected construction-related air quality impacts should be temporary and highly localized.

Minimal spent nuclear fuel activities would occur under this alternative. Therefore, DOE expects that the ambient concentrations levels from normal operations would be similar to those from baseline. **Table 4.7-1 lists nonradioactive emissions from normal operations.** Tables 5.7-1 and 5.7-2 list the maximum potential concentrations for the proposed alternatives; they are all below applicable standards and guidelines. Ambient concentrations from Alternative 1 activities will be below applicable standards and guidelines.

5.7.1.2 Radiological Air Quality. No radiological impacts to the environment would result

from construction activities.

No additional facilities that would be in operation for this alternative would produce radionuclide emissions. Therefore, for normal operations, doses to the maximally exposed individual, the population, and workers would be equivalent to baseline doses, as listed in Table 5.7-3. Table 5.7-4 lists associated emission rates.

Table 5.7-1. Maximum impacts to nonradiological air quality from spent nuclear fuel - criteria pollutants. ,b

Pollutant	Averaging time	Applicable standard (-g/m3)	Maximum baseline concentration (-g/m3)	Baseline plus maximum alternativec (-g/m3)	Percent of standard
Carbon monoxide	1-hr	40,000	610	610	1.5
	8-hr	10,000	280	280	2.8
Nitrogen dioxide	Annual	100	4	4	4
Lead	Quarterly	1.5	0.001	0.001	<0.1
Particulate matter (PM10)	24-hr	150	80	80	53
	Annual	50	5	5	10
Sulfur dioxide	3-hr	1,300	580	580	45
	24-hr	365	140	140	38
	Annual	80	6	6	7.5

a. Source: Section 5.7 of Volume 2 of this EIS and Belanger et al. (1995).
b. Listed concentrations are the maximum of those calculated at the INEL site boundary, public access roads inside the INEL site boundary, and the Craters of the Moon Wilderness Area.
c. The listed concentrations are the maximums for any of the proposed alternatives.

Table 5.7-2. Maximum impacts to nonradiological air quality from spent nuclear fuel - toxic air pollutants. ,b

Pollutant	Averaging time	Applicable standard (-g/m3)	Maximum baseline concentration (-g/m3)	Impact from maximum alternativec (-g/m3)	Percent of standardd
Ammonia	Annual	1.8y102	6.0y100	1.8y100	1
Benzene	Annual	1.2y10-1	2.9y10-2	2.3y10-2	19
Formaldehyde	Annual	7.7y10-2	1.2y10-2	4.4y10-2	57
Methyl isobutyl ketone	Annual	2.1y103	(e)	2.6y101	1
Hydrofluoric acid	Annual	2.5y101	(e)	1.8y10-2	<0.1
Tributylphosphate	Annual	2.5y101	(e)	6.1y10--2	0.2

a. Source: Section 5.7 of Volume 2 of this EIS and Raudsep (1995).
b. Listed concentrations are the maximum of those calculated at the INEL site boundary, public access roads inside the INEL site boundary, and the Craters of the Moon Wilderness Area.
c. The listed concentrations are the maximums for any of the proposed alternatives, plus new or modified sources expected to become operational after May 1, 1994.
d. In accordance with State of Idaho regulations for toxic air pollutants, the percent of standard is calculated based on concentrations resulting from the alternatives and from new or modified sources that have become operational since May 1, 1994.
e. Baseline concentrations for these pollutants were not analyzed because their emissions were below screening levels.

Table 5.7-3. Annual dose increments by alternative in comparison to the baseline.

Alternative	INEL worker (millirem)	Maximally exposed individual (millirem)	Population (person-rem)b
Baseline	4.3y100c	5.6y10-2	3.4y10-1
1. No Action	3.3y10-4	3.5y10-3	1.0y10-1
2. Decentralization	3.3y10-4	3.5y10-3	1.0y10-1
3. 1992/1993 Planning Basisc	3.3y10-3	8.0y10-3	1.9y10-1
4a. Regionalization by Fuel Type	3.3y10-3	8.0y10-3	1.9y10-1
4b(1). Regionalization by Geography (INEL)d	4.2y10-3	4.8y10-2	3.9y10-1
4b(2). Regionalization by Geography (Elsewhere)	7.0y10-5	3.9y10-3	8.3y10-2
5a. Centralization at Other DOE Sites	7.0y10-5	3.9y10-3	8.3y10-2
5b. Centralization at the INEL	4.2y10-3	4.8y10-2	3.9y10-1

a. Source: Section 5.7 of Volume 2 of this EIS.
b. Population dose is calculated based on the projected population in 2000 or 2010 whichever is higher.
c. Baseline worker dose includes the maximum projected operation of the portable water treatment unit at the Power Burst Facility area. However, the operation would be temporary (1 to 2 years) and is not representative of a permanent increase in the baseline. If this facility were not included, the baseline dose to

the worker would be about 0.2 millirem per year.

d. Alternative 4b(1) doses are slightly less than Alternative 5b doses.

5.7.2 Alternative 2 - Decentralization

5.7.2.1 Nonradiological Air Quality. Potential impacts to air quality from construction

activities would include fugitive dust and exhaust emissions from support equipment. The modeling assessment showed that the expected construction-related air quality impacts should be temporary and highly localized.

Emissions resulting from normal operations under this alternative would include baseline emissions and those resulting from the startup of the proposed facilities. Emission rates associated with startup would be less than 1 percent of those from normal operations. Tables 5.7-1 and 5.7-2 list the maximum concentrations predicted for the proposed alternatives. Ambient concentrations from Alternative 2 activities would be below applicable standards and guidelines.

Table 5.7-4. Radionuclide emissions by alternative for spent nuclear fuel projects.

Project and Location	Associated Alternative	Radionuclides and Emission Rates (Ci/yr)										
		H-3/ C-14	Co-60	Kr-85	Xe-131m/ Xe-133	Sr-90/ Y-90	Sb-125	I-129/ I-131	Cs-134 Cs-137	Plutonium	Am-241	Others
TAN Pool Fuel Transfer Project (Test Area North)	1, 2, 3, 4a 4b(1), 5b											
a. Drying operations		9.6y102	-	-	-	2.9y10-2	-	3.4y10-2	-	6.6y10-4	2.2y10-4	-
b. Storage operations		3.9y10-1	-	-	-	-	-	-	-	-	-	-
Additional Increased Rack Capacity (Idaho Chemical Processing Plant)	3, 4a, 4b(1), 5b	2.0y10-1	1.2y10-8	-	-	3.8y10-7	1.0y10-4	-	1.3y10-5	-	-	3.1y10-6
Dry Fuels Storage Facility (Idaho Chemical Processing Plant)	3, 4a, 4b(1), 4b(2), 5a, 5b	1.8y10-2	1.9y10-6	-	-	1.8y10-5	2.2y10-3	4.2y10-3	6.8y10-7	2.6y10-7	-	1.9y10-5
Fort St. Vrain Spent Fuel Storage (Idaho Chemical Processing Plant)	3, 4a, 4b(1), 5b	-	5.6y10-8	-	-	1.8y10-6	-	-	2.4y10-7	5.6y10-7	-	2.4y10-7
Increased Rack Capacity (Idaho Chemical Processing Plant)	3, 4a, 4b(1), 5b	2.0y10-1	1.2y10-8	-	-	3.8y10-7	1.0y10-4	-	1.3y10-5	-	-	3.1y10-6
EBR-II Blanket Treatment (Argonne National Laboratory - West)	3, 4a, 4b(1), 5b	1.6y102	-	4.9y103	5.1y101	-	-	-	-	-	-	-
Electrometallurgical Process Demonstration Project (Argonne National Laboratory - West)	3, 4a, 4b(1), 4b(2), 5a, 5b	8.4y102	-	1.4y104	1.3y102	-	-	-	-	-	-	-
Spent Fuel Processing Facility	4b(1), 5b	3.1y103	1.9y10-6	5.0y105	-	5.8y10-2	1.6y101	4.4y10-1	1.8y10-1	7.7y10-3	-	2.1y10-1

a. Source: Appendix F-3 of Volume 2 of this EIS.

5.7.2.2 Radiological Air Quality. No radiological impacts to the environment would result

from construction activities.

Emissions resulting from normal operations under this alternative would include the baseline emissions and those resulting from the startup of the proposed facilities. Table 5.7-4 lists emission rates for the spent nuclear fuel alternatives, including Decentralization. Table 5.7-3 lists the resulting doses to the maximally exposed individual, the population, and workers. These values are small in comparison to the National Emission Standards for Hazardous Air Pollutants dose limit of 10 millirem per year, the dose limit received from background sources of 351 millirem per year, and the population dose from background sources of 40,000 person-rem.

5.7.3 Alternative 3 - 1992/1993 Planning Basis

5.7.3.1 Nonradiological Air Quality. Potential impacts to air quality from construction

activities would include fugitive dust and exhaust emissions from support equipment. The modeling assessment showed that expected construction-related air quality impacts should be temporary and highly localized.

Emissions resulting from normal operations under this alternative would include baseline emissions and those resulting from the proposed facilities. Emission rates associated with startup would be less than 1 percent of those from normal operations. Tables 5.7-1 and 5.7-2 list the maximum potential concentrations for the proposed alternatives. Ambient concentrations from Alternative 3 activities would be below applicable standards and guidelines.

5.7.3.2 Radiological Air Quality. No radiological impacts to the environment would result

from construction activities.

Emissions resulting from normal operations under this alternative would include baseline emissions and those resulting from the startup of the proposed facilities. Table 5.7-4 lists emission rates for the spent nuclear fuel alternatives. Table 5.7-3 lists the resulting doses to the maximally exposed individual, the population, and workers. These values are small in comparison to the National Emission Standards for Hazardous Air Pollutants dose limit of 10 millirem per year, the dose limit received from background sources of 351 millirem per year, and the population dose from background sources of 40,000 person-rem.

5.7.4 Alternative 4a - Regionalization by Fuel Type

5.7.4.1 Nonradiological Air Quality. Potential impacts to air quality from construction

activities would include fugitive dust and exhaust emissions from support equipment. The modeling assessment showed that the expected construction-related air quality impacts should be temporary and highly localized.

Emissions resulting from normal operation under this alternative would include baseline emissions and those resulting from the startup of the proposed facilities. Emission rates associated with startup would be less than 1 percent of those from normal operations. Tables 5.7-1 and 5.7-2 list the maximum potential concentrations for the proposed alternatives. Ambient concentrations from Alternative 4 activities would be below applicable standards and guidelines.

5.7.4.2 Radiological Air Quality. No radiological impacts to the environment would result

from construction activities.

Emissions resulting from normal operation under this alternative would include baseline emissions and those resulting from the proposed facilities. Table 5.7-4 lists emission rates for spent nuclear fuel alternatives including Regionalization. Table 5.7-3 lists the resulting doses to the maximally exposed individual, the population, and workers. These values are small in comparison to the National Emission Standards for Hazardous Air Pollutants dose limit of 10 millirem per year, the dose limit received from background sources of 351 millirem per year, and the population dose from background sources of 40,000 person-rem.

5.7.5 Alternative 4b(1) - Regionalization by Geography (INEL)

5.7.5.1 Nonradiological Air Quality. Potential impacts to air quality from construction

activities would include fugitive dust and exhaust emissions from support equipment. The modeling assessment showed that the expected construction-related air quality impacts should be temporary and highly localized.

Emissions resulting from normal operation under this alternative would include baseline emissions and those resulting from the startup of the proposed facilities. Emission rates associated with startup would be less than 1 percent of those from normal operations. Tables 5.7-1 and 5.7-2 list the maximum potential concentrations from the proposed alternatives. Ambient concentrations from Alternative 4b(1) activities would be below applicable standards and guidelines.

5.7.5.2 Radiological Air Quality. No radiological impacts to the environment would result

from construction activities.

Emissions resulting from normal operation under this alternative would include baseline emissions and those resulting from the proposed facilities. Table 5.7-4 lists associated emission rates for spent nuclear fuel alternatives including Regionalization by Geography (INEL). Table 5.7-3 lists resulting doses to the maximally exposed individual, the population, and workers. These values are small in comparison to the National Emission Standards for Hazardous Air Pollutants dose limit of 10 millirem per year, the dose limit received from background sources of 351 millirem per year, and the population dose from background sources of 40,000 person-rem.

5.7.6 Alternative 4b(2) - Regionalization by Geography (Elsewhere)

5.7.6.1 Nonradiological Air Quality. Potential impacts to air quality from construction

activities would include fugitive dust and exhaust emissions from support equipment. The modeling assessment showed that the expected construction-related air quality impacts should be temporary and highly localized.

Emissions resulting from normal operation under this alternative would include baseline emissions and those resulting from the startup of the proposed facilities. Emission rates associated with startup would be less than 1 percent of those from normal operations. Tables 5.7-1 and 5.7-2 list the maximum potential concentrations from the proposed alternatives. Ambient concentrations from Alternative 4b(2) activities would be below applicable standards and guidelines.

5.7.6.2 Radiological Air Quality. No radiological impacts to the environment would result

from construction activities.

Emissions resulting from normal operation under this alternative would include baseline emissions and those resulting from the proposed facilities. Table 5.7-4 lists associated emission rates for spent nuclear fuel alternatives including Regionalization by Geography (Elsewhere). Table 5.7-3 lists resulting doses to the maximally exposed individual, the population, and workers. These values are small in comparison to the National Emission Standards for Hazardous Air Pollutants dose limit of

10 millirem per year, the dose limit received from background sources of 351 millirem per year, and the population dose from background sources of 40,000 person-rem.

5.7.7 Alternative 5a - Centralization at Other DOE Sites

5.7.7.1 Nonradiological Air Quality. Potential impacts to air quality from construction

activities would include fugitive dust and exhaust emissions from support equipment. The modeling assessment showed that the expected construction-related air quality impacts should be temporary and highly localized.

Emissions resulting from normal operation under this alternative would include baseline emissions and those resulting from the startup of the proposed facilities. Emission rates associated with startup would be less than 1 percent of those from normal operations. Tables 5.7-1 and 5.7-2 list the maximum potential concentrations from the proposed alternatives. Ambient concentrations from Alternative 5a activities would be below applicable standards and guidelines.

5.7.7.2 Radiological Air Quality. No radiological impacts to the environment would result

from construction activities.

Emissions resulting from normal operation under this alternative would include baseline emissions and those resulting from the proposed facilities. Table 5.7-4 lists associated emission rates for spent nuclear fuel alternatives including Centralization at other DOE sites. Table 5.7-3 lists resulting doses to the maximally exposed individual, the population, and workers. These values are small in comparison to the National Emission Standards for Hazardous Air Pollutants dose limit of 10 millirem per year, the dose limit received from background sources of 351 millirem per year, and the population dose from background sources of 40,000 person-rem.

5.7.8 Alternative 5b - Centralization at the INEL

5.7.8.1 Nonradiological Air Quality. Potential impacts to air quality from construction

activities would include fugitive dust and exhaust emissions from support equipment. The modeling assessment showed that the expected construction-related air quality impacts should be temporary and highly localized.

Emissions resulting from normal operation under this alternative would include baseline emissions and those resulting from the proposed facilities. Emission rates associated with the startup of the proposed facilities would be less than 1 percent of those from normal operations. Tables 5.7-1 and 5.7-2 list the maximum potential concentrations from the proposed alternatives. Ambient concentrations from Alternative 5b activities would be below applicable standards and guidelines.

5.7.8.2 Radiological Air Quality. No radiological impacts to the environment would result

from construction activities.

Emissions resulting from normal operation under this alternative would include baseline emissions and those resulting from startup of the proposed facilities. Table 5.7-4 lists associated emission rates for spent nuclear fuel alternatives including Centralization at the INEL. Table 5.7-3 lists resulting doses to the maximally exposed individual, the population, and workers. These values are small in comparison to the National Emission Standards for Hazardous Air Pollutants dose limit of 10 millirem per year, the dose limit received from background sources of 351 millirem per year, and the population dose from background sources of 40,000 person-rem.

5.8 Water Resources and Related Consequences

This section discusses potential environmental consequences to water resources under the five spent nuclear fuel management alternatives. DOE evaluated each alternative with respect to its impacts on water quality (both surface and subsurface water), water use, and human health.

Any liquid effluents from facilities proposed for the spent nuclear fuel alternatives would be in tanks or lined evaporation basins. Under normal operating conditions, radioactive discharges to the soil or directly to the aquifer would not occur. Creed (1994) presents spent nuclear fuel water quality data for the analysis of the potential impacts resulting from a hypothetical leak of 20 liters (5 gallons) per day from secondary containment around the SNF storage pools during operations. Arnett (1994) addresses the effects that this leak could have on the quality of subsurface water resources. Preliminary results indicate that there will be no contaminants above maximum contaminant levels at the INEL boundary resulting from the postulated operational leak. Some storage pools have had leakage in the past. However, based on the bounding accident scenario for high-level waste tank failure, leakage during the implementation of the selected spent nuclear fuel management alternative would cause negligible impacts to water resources (Bowman 1994). None of the proposed alternatives for the management of spent nuclear fuel would result in any renewed discharges to infiltration ponds. Section 5.15 discusses potential releases of hazardous or radioactive liquids as a result of accidents.

With respect to water usage, Alternative 4b(l) [Regionalization by Geography (INEL)] and Alternative Sb (Centralization at the INEL) would consume the largest volume of water- 1.5 million cubic meters (400 million gallons) over 40 years. The greatest water consumption rate for these alternatives would be 50,000 cubic meters (13 million gallons) per year (Hendrickson 1995). This incremental usage would represent approximately a 0.7 percent increase over the total average withdrawal rate at the INEL of 7.4 million cubic meters (1.9 billion gallons) per year. The INEL's consumptive use water right is 43 million cubic meters (11.4 billion gallons) per year. Therefore, Alternatives 4b(I) and Sb would have negligible impact on the quantity of water in the Eastern Snake River Plain Aquifer.

5.9 Ecology

DOE expects that construction impacts, which would include the loss of some wildlife habitat due to land clearing and facility development, would be greatest under Alternative 4b(1) [Regionalization by Geography (INEL)] and Alternative 5b (Centralization at the INEL). Because this construction activity would take place either within the boundaries of heavily developed areas or adjacent to those areas, it would have minimal impact on ecological resources. However, construction activities could provide opportunities for the spread of exotic plant species (e.g., cheatgrass and Russian thistle).

There would be no construction impacts to wetlands, which would be excluded from development, and impacts to threatened and endangered species would be unlikely, given the location (previously-developed areas) and the maximum size [approximately 31 acres (0.125 square kilometers)] of the affected area. Construction activities at the INEL probably would not affect either of the endangered species identified in Section 4.9.3 (the bald eagle and peregrine falcon). Both of these birds of prey are associated with riparian areas, wetlands, and larger bodies of water (e.g., reservoirs) and inhabit dry upland areas only temporarily when migrating (National Geographic Society 1987). Disturbance to other sensitive (but not Federally-listed) species identified in Section 4.9.3 (e.g., the burrowing owl, northern goshawk, ferruginous hawk, Swainson's hawk, gyrfalcon, Townsend's western big-eared bat, and pygmy rabbit) would be possible but unlikely, given the scale of the planned construction. Any impacts would be negligible and short lived, lasting only as long as the construction activities.

Representative impacts from operations would include the disturbance and displacement of animals (such as the pronghorn) caused by the movement and noise of personnel, equipment, and vehicles. Such impacts would be greatest under Alternative 4b(1) [Regionalization by Geography (INEL)] and Alternative 5b (Centralization at INEL), which would involve a generally higher level of operational activity; however, these impacts would be minor under all the proposed alternatives.

5.10 Noise

As discussed in Section 4.10, noises generated on the INEL do not travel off the site at levels that affect the general population. Therefore, INEL noise impacts for each alternative would be limited to those resulting from the transportation of personnel and materials to and from the site that would affect nearby communities, and from onsite sources that could affect wildlife near those sources.

Transportation noises would be a function of the size of the workforce (e.g., an increased workforce would result in increased employee traffic and corresponding increases in deliveries by truck and rail; a decreased workforce would result in decreased employee traffic and corresponding decreases in deliveries). This analysis of traffic noise considered railroad noise and noise from major roadways that provide access to the INEL. DOE does not expect the number of freight trains per day in the region and through the site to change as a result of any of the alternatives. Rail shipments of spent nuclear fuel, regardless of the alternative, would be a small fraction of the rail traffic on the Blackfoot-to-Arco Branch of the Union Pacific System line that crosses the INEL. The vehicles that transport employees and personnel on roads would be the principal source of community noise impacts near the INEL.

This analysis used the day-night average sound level to assess community noise, as suggested by the EPA (EPA 1974, 1982) and the Federal Interagency Committee on Noise (FICON 1992). The analysis based its estimate of the change in day-night average sound level from the baseline noise level for each alternative on projected changes in employment and traffic levels. The analysis also considers the combination of construction and operation employment. The baseline noise level is comparable to that for the No-Action alternative. Section 4.10 discusses levels representative of the No-Action alternative. The traffic noise analysis considered U.S. Highway 20, which employees use to access the INEL from Idaho Falls. Changes in noise level below 3 decibels probably would not result in a change in community reaction (FICON 1992).

The new employment associated with each alternative is a small percentage of the total onsite workforce. The maximum new employment of about 375 INEL onsite jobs would occur with Alternatives 3, 4a, 4b(1), and 5b during the peak construction period beginning in 2001 (see Section 5.3, Socioeconomics). No new operations employment is projected for any of the alternatives except Alternatives 4b(1) and 5b for which there would be 25 new jobs beginning in 2007. The cumulative onsite workforce under each alternative would be greatest in 1995 and would decrease thereafter. The peak cumulative onsite workforce for Alternatives 4b(2) and 5a would increase in 1995 by less than 1 percent compared to the No-Action baseline. There would be a corresponding increase in private vehicle and truck trips to the site. The day-night sound level (DNL) at 15 meters (50 feet) from the roads that provide access to the INEL probably would increase by less than 1 decibel. The peak cumulative onsite workforce for Alternative 2 in 1995 would be the same as that for the No-Action baseline.

For any of the alternatives, truck activity would consist of a few trips per day to and from the site carrying spent nuclear fuel. This increase in truck trips would not result in a perceptible increase in traffic noise levels along the routes to the INEL. The day-night average sound level along U.S. Highway 20 and other access routes probably would decrease slightly as a result of the anticipated overall decrease in employment levels at the INEL. DOE expects no change in the community reaction to noise along this route and other access routes. No mitigation efforts would be required.

5.11 Traffic and Transportation

5.11.1 Introduction

Spent nuclear fuel management activities involve the transportation of spent nuclear fuel inside the boundaries of the INEL (onsite) and on highways and rail systems outside the boundaries of the INEL (offsite). This section summarizes the methods of analysis used to determine the environmental consequences of onsite transportation of nonnaval spent nuclear fuel under normal conditions (incident-free) and of transportation accidents. The impacts include doses and health effects. Appendices D and I of Volume 1 address consequences of shipments to or from the INEL that involve other DOE sites and spent nuclear fuel-related locations.

5.11.2 Methodology

5.11.2.1 Incident-Free Transpodation. Radiological impacts were determined for two groups of people during normal incident-free transportation: (1) crewmen (drivers) and (2) members of the public. Members of the public are persons sharing the transport link (on-link). On-link doses were determined for Onsite shipments because members of the public have access to the majority of the roads on the INEL. Radiological impacts were calculated using the RADTRAN 4 (Neuhauser and Kanipe 1992) and RISKIND (Yuan et al. 1993) computer codes.

The magnitude of the incident-free dose depends mainly on the Transport Index of the shipment and the on-link vehicle densities. The Transport Index is defined as the dose rate at 1 meter (3.28 feet) from the surface of a radioactive package; it is measured in millirem per hour. Spent nuclear fuel was assigned a dose rate of 14 millirem per hour at 1 meter from the shipping container. This dose rate yielded a dose rate of 10 millirem per hour at 2 meters (6.56 feet) from the edge of the transport vehicle, which is the regulatory limit for an exclusive use vehicle (see Madsen et al. 1986).

Radiological doses were converted to cancer fatalities using risk conversion factors of 5.0 x lO~ fatal cancer per person-rem for members of the public and 4.0 x 10A fatal cancers per person-rem for workers. These risk conversion factors are from Publication 60 of the International Commission on Radiological Protection (ICRP 1991).

Because the onsite transportation of spent nuclear fuel at the INEL is considered rural, no incident-free nonradiological risk (from exhaust emissions and dust resuspension) was calculated.

5.11.2.2 Accidents. The doses of the maximum reasonably foreseeable onsite spent nuclear fuel transportation accident were calculated using the RISKIND computer code. Doses were analyzed for generic rural and suburban population densities, assuming 6 persons per square kilometer for rural areas and 719 persons per square kilometer for suburban areas. Areas within 80 kilometers (50 miles) of INEL have population densities between rural and suburban but are closer to the generic rural population density. Doses were also assessed under both neutral and stable atmospheric conditions. Radiation doses calculated were used to estimate the potential for fatal cancers in the exposed population using risk factors developed by the International Commission on Radiological Protection (ICRP 1991).

The probability of the maximum reasonably foreseeable onsite spent nuclear fuel transportation accident was estimated taking into account spent nuclear fuel handling procedures within the Advanced Test Reactor facility as well as factors related to transportation of the spent nuclear fuel. For this accident to occur, errors must occur in loading the wrong spent nuclear fuel into the shipping cask, radiation surveys of the loaded cask fail to detect abnormally high radiation levels, the transport vehicle must breakdown or rollover during the short transit between the Advanced Test Reactor and the Idaho Chemical Processing Plant, and operators fail to ensure that adequate cooling water is maintained inside the cask. The estimated probability of this accident is no greater than once in a million years.

The risk of the onsite spent nuclear fuel transportation accident was estimated by multiplying the accident doses by the accident probability, taking into account the probability of the atmospheric conditions used. The resulting risk value gives a bounding estimate of the annual probability of fatal cancers occurring in the local population due to onsite spent nuclear fuel transportation accidents.

5.11.3 Onsite Spent Nuclear Fuel Shipments

For each spent nuclear fuel management alternative, a small number of onsite DOE spent nuclear fuel shipments would be likely each year as a result of continuing reactor operations at the Advanced Test Reactor and the Experimental Breeder Reactor-li. The alternatives would not affect the operation of these two facilities, thus the shipments be'tween these facilities and the Idaho Chemical Processing Plant, integrated over 40 years, would be the same for each spent nuclear fuel management alternative.

Spent nuclear fuel shipments to the Idaho Chemical Processing Plant from four locations on the INEL (including the Test Reactor Area, Argonne National Laboratory-West, Test Area North, and Power Burst Facility) were evaluated. The number of shipments would not change with alternatives because DOE plans to ship all spent nuclear fuel to the Idaho Chemical Processing Plant. Alternatives that would ship spent nuclear fuel off the site under Regionalization [Alternatives 4a, 4b(1) and 4b(2)] and Centralization (Alterntives Sa and Sb) would ship it first to the Idaho Chemical Processing Plant for canning or other stabilization prior to shipment. DOE estimated the total projected number of shipments over 40 years of operation (1995-2035) from each facility from either historic records or current inventories. DOE based the projected number of shipments for Test Reactor Area and Argonne National Laboratory-West to the Idaho Chemical Processing Plant on historic records for 1987 through 1992, and the doses reflect shipments for 1995 through 2035. The projected number of shipments from Test Area North would include Three Mile Island canisters, Loss of Fluid Test fuel, special case commercial fuel, and non-fuel-bearing components stored in the Test Area North pool. The projected number of shipments from the Power Burst Facility includes all spent nuclear fuel stored at that facility.

Onsite shipments would include those that originated and ended on the INEL site. Shipments that originate or terminate at non-INEL facilities are offsite shipments. Appendixes D and I describe the consequences of naval and DOE offsite spent fuel shipments, respectively. Movements of spent nuclear fuel inside (INEL) facility fences (e.g., from the CPP-603 Underwater Storage Facility to the Fuel Storage Area) are operational transfers, not onsite shipments; therefore, this section does not consider such shipments

5.11.4 Incident-Free Impacts

The occupational and general population collective doses from onsite spent nuclear fuel shipments and the resulting incidence of latent cancer fatalities were calculated. The results are the same regardless of alternative. Occupational radiation exposure would potentially be 3.4 person-rem, resulting in 0.0014 latent cancer fatalities. General population exposure would potentially be 0.088 person-rem, resulting in 0.000044 latent cancer fatalities.

In addition to collective radiation exposure, the maximally exposed individual doses due to INEL onsite SNF shipments were calculated for a driver (occupational exposure), a person following a single shipment, and a person standing beside the road as a single shipment passes by (general member of the public). The calculated dose to a driver would be 1.7 rem, assuming that person drove all shipments over 40 years. The calculated maximally exposed individual dose to a person following a single shipment covering the longest distance from Test Area North to the Idaho Chemical Processing Plant would be 0.015 millirem, and to a person exposed to passing shipment at a distance of 1 meter (3.28 feet), the dose would be 0.0014 millirem (Maheras 1995).

Traffic impacts for the spent nuclear fuel shipments were estimated from data in Heiselmann (1994). The maximum number of spent nuclear fuel shipments of 691 per year would occur with Alternative Sb, Centralization at the INEL. A maximum 23-percent increase in traffic volume per day would occur with this alternative, based on the estimates of the number of trips required for the transport of construction equipment, material, spent nuclear fuel, other wastes, and workers to and from the INEL. Even if this average daily traffic volume were to occur for 1 hour, the maximum traffic volume would increase to 145 vehicles per hour for US 20, US 26, Routes 33 and 22; this would not change the baseline level of service, which is designated as "free flow."

5.11.5 Accident Impacts

An onsite spent nuclear fuel transportation accident involving the inadvertent shipment of a short-cooled fuel element from the Advanced Test Reactor to the Idaho Chemical Processing Plant was considered to be the maximum reasonably foreseeable accident. The melted spent nuclear fuel has potential to relocate into a critical configuration. However, the probability of a criticality accident is much less than 1 x l0(-7) per year and would be considered to be not reasonably foreseeable. Table 5.11-1 lists the calculated maximally exposed individual dose and collective dose to general population in the maximally impacted sector and corresponding risk of fatal cancers. The dose to the maximally exposed individual is considered an occupational exposure.

As listed in Table 5.11-1, the total number of fatal cancers expected in the suburban population affected by the transportation for neutral and stable meteorological conditions would be 11 and 85, respectively. For the neutral case, this would represent a 0.01-percent increase from the number of fatal cancers that would be likely from normal incidence in the affected population. For the stable case, this would represent a 0.20-percent increase from the number of fatal cancers that would be likely from normal incidence in the affected population.

The total number of fatal cancers expected in the rural population affected by the transportation for neutral and stable meteorological conditions would be 0.75 and 6.0, respectively. For the neutral

Table 5.11-1. Impacts from maximum reasonably foreseeable spent nuclear fuel transportation accident on INELa (using generic rural and suburban population densities).

Population density categoryb	Meteorologyc	Accident frequencyd (events/yr)	Dose to MEIe (rem)	Offsite population dose (person-rem)	Risk of fatal cancer per yearf
Rural	Neutral	1.0y10-6	7.6y101	1.5y103	7.5y10-7 (7.5y10-1)
Rural	Stable	1.0y10-7	2.5y102	1.2y104	6.0y10-7 (6.0y100)
Suburban	Neutral	1.0y10-6	7.6y101	2.1y104	1.1y10-5 (1.1y101)
Suburban	Stable	1.0y10-7	2.5y102	1.7y105	8.5y10-6 (8.5y101)

a. Source: Enyeart (1994).

b. Results are for generic rural and suburban population densities. The generic rural population density has an average population of 6 persons per square kilometer; the generic suburban population density has an average population of 719 persons per square kilometer. For comparison, the sector with the highest population density within 80 kilometers (50 miles) is due east of the Idaho Chemical Processing Plant and Test Reactor Area at the INEL with an average population density of 53 persons/km2.

c. Neutral meteorology is characterized by Stability Class D, 4 meters-per-second wind speed, and occuring approximately 50 percent of the time. Stable meteorology is characterized by Stability Class F, 1 meter-per-second wind speed, and occuring approximately 5 percent of the time.

d. Accident frequency includes both the event frequency and the frequency of the meteorology. The frequency of stable meteorology is approximately one-tenth the frequency of neutral meteorology.

e. Maximally exposed individual located at the point of maximum exposure to the airborne release approximately 160 to 390 meters (525 to 1,280 feet) downwind, depending on meteorology. For onsite accidents the maximally exposed individual is assumed to be an INEL worker.

f. Fatal cancer risk = dose times accident frequency times (ICRP 60 risk factor for fatal cancers). The ICRP 60 risk factor is 5.0 y 10-4 fatal cancer per rem for public, 4.0 y 10-4 fatal cancer per rem for workers. For doses of 20 rem or more, the ICRP 60 conversion factor is doubled. Numbers in parentheses indicate the total number of fatal cancers in the population if the accident occurs. The maximally exposed individual dose is considered an occupational exposure.

case, this would represent a 0.09-percent increase from the number of fatal cancers that would be likely from normal incidences in the affected population. For the stable case, this would represent a 1.7-percent increase from the number of fatal cancers that would he likely from normal incidence in the affected population.

The estimated maximum nonradiological occupational and general population traffic fatalities over 40 years due to any of the spent nuclear fuel management alternatives would be 7.1 x 10(-4) and 2.5 x 10(-3), respectively. These estimated fatalities were based on fatality risk factors for spent fuel shipments (Cashwell et. al 1986).

5.11.6 Onsite Mitigative and Preventative Measures

All onsite shipments would be in compliance with DOE ID Directive 5480.3, "Hazardous Materials Packaging and Transportation Safety Requirements." These requirements provide assurance that, under normal conditions, the INEL would meet as-low-as-reasonably-achievable conditions, reasonably foreseeable accident situations (those with a probability of occurrence greater than 1 x 10(-7) per year) would not result in a loss of shielding or containment or a criticality, and an unintentional release of radioactive maSerial would generate a timely response.

DOE would approve the type packages used for onsite shipments or would obtain a Nuclear Regulatory Commission or DOE certificate of compliance. If the Type B onsite package did not have Nuclear Regulatory Commission or DOE certification, the user of the package would have to establish how administrative controls and site-mitigating circumstances would ensure that the package would maintain containment and shielding integrity. The administrative and emergency response considerations would provide sufficient control so that accidents would not result in loss of containment or shielding, in criticality, or in an uncontrolled release of radioactive material that would create a hazard to the health and safety of the public or workers.

In the event of an accident, each DOE site has an established emergency management program. This program incorporates activities associated with emergency planning, preparedness, and response. Participating government agencies with plans that are interrelated with the INEL Emergency Plan for Action include the State of Idaho, Bingham County, Bonneville County, Butte County, Clark County, Jefferson County, the Bureau of Indian Affairs, and Fort Hall Indian Reservation. When an emergency condition exists at a facility, the Emergency Action Director is responsible for recognition, classification, notification, and protective action recommendations. At INEL emergency preparedness resources include fire protection, radiological and hazardous chemical material response, emergency control center, the INEL Warning Communication Center, the INEL Site Emergency Operational Center, and medical facilities.

5.12 Occupational and Public Health and Safety

This section presents DOE's estimates of the health effects from spent nuclear fuel-related activities at the INEL for the following human receptor groups:

- Involved Workers - workers at the facilities involved with spent nuclear fuel alternatives, including existing workers and new hires for selected alternative
- Maximally Exposed Individual (MEI) - person residing at the INEL site boundary
- Population - the general offsite population in the INEL region
- Construction Worker - labor force associated with construction activities
- Nonconstruction Worker - DOE labor force associated with nonconstruction activities

Radiological, chemical, and industrial safety hazards were considered in the estimates.

5.12.1 Radiological Exposure and Health Effects

The measure of impact used for evaluation of potential radiation exposures is risk of fatal cancers. Worker and maximally exposed individual effects are reported as individual radiation dose (in rem) and the estimated lifetime probability of fatal cancer. Population effects are reported as collective radiation dose (in person-rem) and the estimated number of fatal cancers in the affected population. Tables 5.12-1, 5.12-2, 5.12-3, and 5.12-4 summarize the radiological health effects calculations for each alternative.

Activities that workers would perform under each of the alternatives would be similar to those currently performed at the INEL. Therefore, the potential hazards encountered in the workplace would be similar to those that currently exist at the INEL. Further, DOE would mitigate these hazards with occupational and radiological safety programs operating under the same regulatory standards and limits that currently apply at the INEL. For these reasons, DOE anticipates that the average radiation dose

Table 5.12-1. Annual occupational radiation exposure and employment summary.

	No Action (1)	Decentralization (2)	1992/1993 Planning Basis (3)	Regionalization by Fuel Type (4a)b	Centralization at Other DOE Sites (5a)	Centralization at the INEL (5b)
Number of Workers (annual average over years 1995-2004)c	1	1	200	200	10	200
Worker Collective Dosed (person-rem/year)	0.027	0.027	5.4	5.4	0.27	5.4

a. Source: Johnson (1995).
b. Alternative 4b(1), Regionalization by Geography (INEL), values are the same as those for Alternative 5b. Alternative 4b(2), Regionalization by Geography (Elsewhere), values are the same as those for Alternative 5a.
c. This 10-year average yields conservatively high employment; the 40-year average would be lower but data do not exist.
d. Based on thermoluminescence dosimetry records.

Table 5.12-2. Annual nonoccupational radiation exposure summary.

	No Action (1)	Decentralization (2)	1992/1993 Planning Basis (3)	Regionalization by Fuel Type (4a)b	Centralization at Other DOE Sites (5a)	Centralization at the INEL (5b)
MEI Dose (mrem/year)	3.5y10-3	3.5y10-3	8.0y10-3	8.0y10-3	3.9y10-3	4.8y10-2
Population Dosea (person-rem/year)	1.0y10-1	1.0y10-1	1.9y10-1	1.9y10-1	8.3y10-2	3.9y10-1

a. Population dose is calculated based on the projected population in 2000.
b. Alternative 4b(1), Regionalization by Geography (INEL), values are the same as those for Alternative 5b. Alternative 4b(2), Regionalization by Geography (Elsewhere), values are the same as those for Alternative 5a.

Table 5.12-3. Annual fatal cancer incidence and probability summary from radiological exposure.

	No Action (1)	Decentralization (2)	1992/1993 Planning Basis (3)	Regionalization by Fuel Type(4a)b	Centralization at Other DOE Sites (5a)	Centralization at the INEL (5b)
Worker						
probability	1y10-5	1y10-5	1y10-5	1y10-5	1y10-5	1y10-5
incidence	1y10-5	1y10-5	2y10-3	2y10-3	1y10-4	2y10-3
Maximally exposed member of the public						
probability	2y10-9	2y10-9	4y10-9	4y10-9	2y10-9	

2y10-8

Population incidence	5y10-5	5y10-5	1y10-4	1y10-4	4y10-5	2y10-4

a. Risk factors for the worker (4y10-4 probability of occurrence per rem) or offsite population (5y10-4 probability of occurrence per rem) recommended by the International Commission on Radiological Protection (ICRP 1991).

b. Alternative 4b(1), Regionalization by Geography (INEL), values are the same as those for Alternative 5b. Alternative 4b(2), Regionalization by Geography (Elsewhere), values are the same as those for Alternative 5a.

Table 5.12-4. 40-year fatal cancer incidence summary from radiological exposure.

	No Action (1)	Decentralization (2)	1992/1993 Planning Basis (3)	Regionalization by Fuel Type (4a)	Centralization at Other DOE Sites (5a)	Centralization at the INEL (5b)
Workers incidence	4y10-4	4y10-4	8y10-2	8y10-2	4y10-3	8y10-2
Population incidence	2y10-3	2y10-3	4y10-3	4y10-3	2y10-3	8y10-3

a. Alternative 4b(1), Regionalization by Geography (INEL), values are the same as those for Alternative 5b. Alternative 4b(2), Regionalization by Geography (Elsewhere), values are the same as those for Alternative 5a.

and the number of reportable cases of injury and illness would be proportional to the number of workers at the INEL under each alternative.

Table 5.12-1 lists involved worker doses based on an historic annual average dose of 27 mrem determined from thermoluminescent dosimeter data of workers involved in various INEL radiological work over the period 1987 to 1991 (see Appendix F of Volume 2). As mentioned above, the hazards associated with spent nuclear fuel activities are the same as the hazards associated with other INEL activities. Table 5.12-2 lists the exposure summaries for the maximally exposed individual and offsite population, based on radioactive emissions from normal operations and those resulting from startup of proposed facilities for the various alternatives. Note that population collective dose is higher than worker collective dose only under alternatives 1 and 2. For the alternatives, there is only 1 SNF worker averaged over 40 years. The nonoccupational population has more people to be exposed. When the worker population increases under Alternatives 3, 4, and 5, the worker dose becomes higher than the population dose. Section 5.7 presents the exposure information. Dose calculations are based on air emissions only, and not water pathways because none of the alternatives would involve the discharge of pollutants to surface waters or to the subsurface. Section 5.8 summarizes water quality.

Table 5.12-3 summarizes the fatal cancer incidence and probability for workers, maximally exposed individuals, and the offsite population based on the risk factors consistent with those recommended by the International Commission on Radiological Protection (ICRP 1991). For all alternatives, the probability of developing fatal cancer for any individual would be low, with the maximum value of 1 y 10-5 for the involved worker. The calculated incidence of fatal cancer for the total number of workers for each alternative and the offsite population would be less than 1.

Table 5.12-4 summarizes the 40-year projection of fatal cancer incidence associated with the worker and offsite populations. The highest involved worker and offsite population incidence, 0.1 and 0.01, respectively, would be associated with Alternative 5b.

Radiation doses associated with construction activities would be as low as reasonably achievable and no greater than 2 rem per year to any worker. Historical offsite doses associated with the INEL are summarized in the Idaho National Engineering Laboratory Historical Dose Evaluation (DOE 1991). The Centers for Disease Control and Prevention is conducting a more comprehensive reconstruction of doses from INEL operations.

5.12.2 Nonradiological Exposure and Health Effects

The air quality data listed in Tables 5.7-1 and 5.7-2 were used to evaluate health impacts associated with potential exposure to two compound classes, criteria pollutant and toxic. Table 5.7-1 lists five pollutant criteria and Table 5.7-2 lists six toxic air pollutant compounds. The toxic compounds were classified as noncarcinogens or carcinogens, consistent with EPA designations published in the Integrated Risk Information System (IRIS) data base. However, the IRIS data base does not include sufficient data to perform a quantitative inhalation cancer risk assessment.

Nonradiological health effects (hazard indices) for the INEL worker or maximally exposed individual were estimated by summing the ratios of the appropriate pollutant concentrations and their applicable standards presented in Table 5.7-1 and Table 5.7-2. Table 5.7-1 presents criteria pollutant concentrations at public access roads, which are the maximum of those calculated at the INEL site boundary, public access roads inside the INEL site boundary, and the Craters of the Moon Wilderness Area. The hazard index for the five criteria pollutants is less than 1 (0.2) for the workers or the maximally exposed individual, based on concentrations for the longest averaging times presented in **Table 5.7-1.** Table 5.7-2 presents toxic air pollutant concentrations at the public access roads, which are the maximum when compared with concentrations at the INEL site boundary and the Craters of the Moon Wilderness Area. The hazard index for the toxic air pollutants is also less than 1 (0.8) for the workers or the maximally exposed individual, based on concentrations with annual averaging time consideration. Accordingly, health effects are unlikely for either the criteria pollutants or the toxic air pollutants from spent nuclear fuel-related activities. The hazard index is not a statistical probability; therefore, it cannot be interpreted as such.

5.12.3 Industrial Safety

This section describes the following measures of impact for workplace hazards: (1) total reportable injuries and illness and (2) fatalities in the work force. This analysis considered injury and fatality rates for construction workers only since the alternatives do not result in incremental changes in operations employment. Table 5.12-5 lists the maximum annual number of projected injuries and illnesses and fatalities for construction workers by alternatives based on the maximum employment levels for any year between 1995-2035.

Table 5.12-5. Annual industrial safety health effects incidence summary. ,b

	No Action (1)	Decentralization (2)	1992/1993 Planning Basis (3)	Regionalization by Fuel Type (4a)c	Centralization at other DOE Sites (5a)	Centralization at the INEL (5b)
Construction workers						
Injury/illness	0	0	23	23	3	23
Fatality	0	0	<1	<1	<1	<1

a. 1988-1992 averages for occupational injury/illness and fatality rates for DOE and contractor employees.
b. Sources: DOE (1993b) and Section 5.3 of this appendix.
c. Alternative 4b(1) values are the same as those for Alternative 5b. Alternative 4b(2) values are the same as those for Alternative 5a.

5.13 Idaho National Engineering Laboratory Services

This section discusses the potential impacts from spent nuclear fuel management on utilities and energy at the INEL. It considers the consumption of water, electrical energy, fossil-based fuels, and wastewater discharge at the INEL site.

5.13.1 Construction

Table 5.13-1 summarizes estimates of annual requirements for electricity, water, wastewater, and diesel fuel for construction activities associated with each alternative and compares them to projected 1995 use levels for these resources. In general, the smallest increase in the demand for site services would result from Alternatives 4b(2) and 5a [Regionalization by Geography (Elsewhere) and Centralization at Other DOE Sites] and the largest increase would be associated with Alternatives 4b(1) and 5b [Regionalization by Geography (INEL) and Centralization at INEL].

Table 5.13-1. Estimated increase in annual electricity, water, wastewater treatment, and fuel requirements for construction activities associated with each alternative.

Service	Projected 1995 usage w/o Alternative	Estimated additional demand construction			
		Alternatives 1 and 2	Alternatives 3 and 4a	Alternatives 4b(1) and 5b	Alternatives 4b(2) and 5a
Electricity (MWHa per year)	208,000	71	150	2,100	10
Water (millions of liters per year)b	6,450	No increase	2.1	2.2	0.5
Sanitary wastewater (millions of liters per year)	540	No increase	1.5	4.5	0.5
Diesel fuel (liters per year)	5,830,000	6,400	8,500	14,000	1,500

a. MWH = megawatt hours.
b. To convert liters to gallons, multiply by 0.264.
Source: Hendrickson (1995).

Under Alternatives 4b(1) and 5b, the estimated annual increases in utility and energy usage rates from construction activities would be 2,100 megawatt-hours of electricity, 2.2 million liters (580,000 gallons) of water, 4.5 million liters (1,200,000 gallons) of wastewater discharge, and 14,000 liters (3,700 gallons) of diesel fuel. These changes represent modest increases ranging from near zero percent to 1.0 percent above projected 1995 usage levels and are well within current system capabilities and usage limits (see Section 4.13). The other alternatives would result in smaller increases in energy usage and would have no adverse impact on utility services at the INEL.

5.13.2 Operations

Table 5.13-2 summarizes estimates of annual requirements for electricity, water, wastewater, and fuel for operations activities associated with each alternative and compares them to project 1995 INEL usage of these resources. In general, the smallest increase in the demand for site services would result from Alternatives 1 and 2 (No-Action and Decentralization) and the largest would be associated with Alternatives 4b(1) and 5b [Regionalization by Geography (INEL) and Centralization at INEL].

Table 5.13-2. Estimated increase in annual electricity, water, wastewater treatment, and fuel requirements for operations activities associated with each alternative.

Service	Projected 1995 usage w/o Alternative	Estimated additional demand operation			
		Alternatives 1 and 2	Alternatives 3 and 4a	Alternatives 4b(1) and 5b	Alternatives 4b(2) and 5a
Electricity (MWHa per year)	208,000	180	2,200	11,000	2,000
Water (millions of liters per year)b	6,450	No increase	No increase	48	No increase
Sanitary wastewater (millions of liters per year)c	540	No increase	No increase	0.3	No increase
Fuel oil (liters per year)	11,100,000	28,000	330,000	1,100,000	300,000

a. MWH = megawatt hours.
b. To convert liters to gallons, multiply by 0.264.
c. Some industrial wastewater, such as steam condensate, is also discharged to evaporation ponds and injection wells.
Sources: Hendrickson (1995).

Under Alternatives 4b(1) and 5b, the estimated annual increases in utility and energy usage rates from operations activities would be 11,000 megawatt-hours of electricity, 48 million liters (13 million gallons) of water, 0.3 million liters (79,000 gallons) of wastewater, and 1,100,000 liters (290,000 gallons) of fuel oil. These changes represent modest increases ranging from near zero percent to 10 percent and are well within current system capabilities and usage limits (see Section 4.13). The other alternatives would result in smaller increases in energy usage and would have no adverse impact on utility services at the INEL.

5.14 Materials and Waste Management

This section discusses the impacts to the management of materials and wastes at the INEL site and Idaho Falls facilities as a result of the implementation of the spent nuclear fuel management alternatives. Alternatives 4b(1), and 5b, both with the spent fuel processing option, each establish the upper bound of potential impacts on projected rates of generation, treatment, storage, and disposal inventories of materials and wastes. Table 5.14-1 and 5.14-2 summarize waste generation projections for each alternative. The tables present average generating rates over the life cycle of each alternative and maximum annual increments over peak generation periods.

5.14.1 Alternative 1 - No Action

Under the No Action Alternative, 9 cubic meters of industrial solid waste would be generated during construction of the Alternate Fuel Storage Facility for the TAN Pool Fuel Transfer Project at the Idaho Chemical Processing Plant. At the completion of this project in 1998, there would be 485 cubic meters of non-fuel solid low-level waste consisting of Three Mile Island hardware and metals that would be removed and dispositioned in a separate project. These impacts apply also to the description of impacts for the other spent nuclear fuel management alternatives with the exception of Alternatives 4b(2) and 5a. The non-fuel solid low-level waste is already existing; therefore, it is not included in Table 5.14-1 as an increase in low-level waste generation.

5.14.2 Alternative 2 - Decentralization

In general, the character of the impacts to materials and waste management would be similar to those under the No Action Alternative.

5.14.3 Alternative 3 - 1992/1993 Planning Basis

Industrial solid waste would be generated from construction and operation of the various SNF projects under Alternative 3. This nonradioactive waste would be disposed of in the Central Facilities Area landfill. Landfill space is nonrestrictive for industrial solid waste disposal. Construction phase activities would generate a cumulative total of 620 cubic meters of industrial and commercial solid

Table 5.14-1. Average annual waste generation projections for selected SNF management alternatives at INEL.

Alternative	Waste type	Phase	Period (years)	Average annual increment over 1995 baseline: Increase (percent)	Average annual increment over 1995 baseline: Annual rate (cubic meters per year)
No Action (Alternative 1) and Decentralization (Alternative 2)	Industrial	Construction	1995-1996	0.02	9
1992/1993 Planning Basis (Alternative 3) and Regionalization by Fuel Type (Alternative 4a)	Industrial	Construction	1995-2005	0.1	62
		Operation	1996-2035	1.2	600
	Low-Levelb,c	Construction	1995-1999		

8.6 370

Operation 1996-2035

4.6 200

High-Level Operation 1996-2024

0.1 3

Mixed Low-Level Operation 1996-2024

<0.1 <1

Transuranic Operation 1996-2024

530 32

Regionalization by Geography (INEL) Industrial Construction 1995-2008

0.6 290

[Alternative 4b(1)] and Centralization at INEL Operation 1996-2035

5.0 2,600

(Alternative 5b) Low-Levelb,c Construction 1995-1999

8.6 370

Operation 1996-2035

9.6 410

High-Level Operation 1996-2035

15.7 120

Mixed Low-Level Operation 1996-2024

<0.1 <1

Transuranic Operation 1996-2024

530 32

Regionalization by Geography (Elsewhere) Industrial Construction 1995-1996

<0.1 50

[Alternative 4b(2)] and Centralization at Other Operation 1996-2024

0.4 210

DOE Sites (Alternative 5a) Low-Level Operation 1996-2024

1.9 83

High-Level Operation 1996-2024

0.1 3

Mixed Low-Level Operation 1996-2024

<0.1 <1

Transuranic Operation 1996-2024

530 32

a. Source: Appendix C of Volume 2 of this EIS.

b. Low-level waste from TAN Pool Fuel Transfer Project to be removed and dispositioned in a separate project not included for any alternatives.

c. Low-level waste generated from dispositioning and decontamination of fuel racks not included in any alternatives.

Table 5.14-2. Peak waste generation highlights for selected SNF management alternatives at INEL.

Maximum increment over 1995 baseline

Alternative Waste type Phase Period

Increase Annual rate

(years) (percent) (cubic meters per year)

No Action (Alternative 1) and Decentralization Industrial Construction 1995-

1996 0.02 9

(Alternative 2)

1992/1993 Planning Basis Industrial Construction 1995-

1996 0.4 220

(Alternative 3) and Regionalization by Fuel Operation 2005-

2021 1.6 810

Type (Alternative 4a) Low-Levelb,c Construction 1995-

1997 13.4 570

Operation 2005-

2024 6.1 260

Concurrent Activityd 1996-

1997 14.2 610

High-Level Operation 1997-

1998 0.2 6

Mixed Low-Level Operation 1997-

1998 <0.1 <1

Transuranic Operation 1997-

1998 600 36

Regionalization by Geography (INEL) Industrial Construction 1999-

2006 0.9 450

[Alternative 4b(1)] and Centralization at INEL Operation 2008-

2021 6.8 3,500

(Alternative 5b) Low-Levelb,c Construction 1995-

1997 13.4 570

Operation 2008-

2024 13.3 570

Concurrent Activityd 1996-

1997 14.2 610

High-Level Operation 2005-

2024 21.1 160

Mixed Low-Level Operation 1997-

			1998	<0.1	<1
	Transuranic	Operation	1997-1998	600	36
Regionalization by Geography (Elsewhere) [Alternative 4b(2)] and Centralization at Other DOE Sites (Alternative 5a)	Industrial	Construction	1995-1996	<0.1	50
		Operation	1996-2024	0.4	210
	Low-Level	Operation	1996-2010	3.1	130
	High-Level	Operation	1996-2024	0.1	3
	Mixed Low-Level	Operation	1996-2024	<0.1	<1
	Transuranic	Operation	1996-2024	530	32

a. Source: Appendix C of Volume 2 of this EIS.
b. Low-level waste from TAN Pool Fuel Transfer Project to be removed and dispositioned in a separate project not included for any alternatives.
c. Low-level waste generated from dispositioning and decontamination of fuel racks not included in any alternatives.
d. Construction and operations occurring simultaneously.

waste. The Fuel Receiving, Canning, Characterization, and Shipping Facility will generate the most industrial waste of any of the projects, 490 cubic meters per year from 2005 through 2035.

In addition, the Fuel Receiving, Canning, Characterization, and Shipping Facility will generate 220 cubic meters per year of low-level waste during the same period. The Dry Storage Facility would generate an additional 5 cubic meters of low-level waste annually from 2005 through 2035. Including liquid low-level waste, the Increased Rack Capacity and Additional Increased Rack Capacity projects would increase generation rates by 570 cubic meters annually during construction from 1995 through 1997. Low-level waste would decrease to approximately 160 cubic meters per year from 1997 through 1999 with the completion of the Increased Rack Capacity project. Liquid low-level waste would be disposed in existing liquid waste processing systems at the Idaho Chemical Processing Plant. Solid radioactive wastes would be packaged and disposed of at the Radioactive Waste Management Complex, or incinerated at the Waste Experimental Reduction Facility, whichever is appropriate. Low-level waste from reracking fuel racks for the Increased Rack Capacity Project will be decontaminated and dispositioned by a licensed commercial vendor.

Experimental Breeder Reactor-II Blanket Treatment will generate 7 cubic meters of low-level waste for 1 year from 1997 to 1998.

The storage of low-level waste for incineration is not considered to be restrictive between 1995 through 2005. However, beyond 2005, low-level waste storage capacity may become strained. Use of commercial facilities to incinerate the backlog of low-level waste is under consideration in order to reduce or prevent the accumulation of low-level waste, but no firm commitment or contract has yet been established (EG&G 1993a).

The Radioactive Waste Management Complex appears to have adequate disposal capacity for low-level waste between 1995 and 2005. However, beyond 2005, additional capacity may be required. Excess capacity would be provided with the development of the proposed Low-Level Waste/Mixed Low-Level Waste Disposal Facility (EG&G 1993a).

The Electrometallurgical Process Demonstration Project will generate high-level, mixed low-level, low-level, transuranic, and industrial wastes from the demonstration and testing of new spent fuel management processes from 1996 through 2024.

Experimental Breeder Reactor-II Blanket Treatment will also generate high-level, mixed low-level, and transuranic wastes.

High-level waste would be immobilized after 2005, and may eventually be transported to a Federal high-level waste and spent nuclear fuel repository for disposal. Transuranic waste meeting waste acceptance criteria to be developed could be shipped to a potential Federal repository for disposal should one be selected (EG&G 1993a).

5.14.4 Alternative 4a - Regionalization by Fuel Type

In general, the character of the impacts to materials and waste management would be similar to those under Alternative 3.

5.14.5 Alternative 4b(1) - Regionalization by Geography (INEL)

The character and intensity of impacts on waste management activities at the INEL are similar to those under Alternatives 3 and 4a for some of the SNF management projects including the TAN Pool Fuel Transfer Project at the Idaho Chemical Processing Plant; the Increased Rack Capacity and Additional Increased Rack Capacity projects; the Experimental Breeder Reactor-II Blanket Treatment facility; and the Electrometallurgical Process Demonstration Project. Under Alternative 4b(1), the Dry Fuel Storage Facility is expanded and Fuel Receiving, Canning/Characterization, and Shipping Facility waste streams decrease relative to Alternatives 3 and 4a; however, the net effect of these differences on industrial/commercial solid waste generation and low-level waste generation for both construction and operation results in waste generation rates similar to those under Alternatives 3 and 4a.

The increase in average and peak generation rates over Alternatives 3 and 4a (Tables 5.14-1 and 5.14-2) is due to the Spent Fuel Processing option included under Alternative 4b(1), which accounts for the relative increase in generation rates over Alternatives 3 and 4a. Fuel processing would be done in order to stabilize the spent nuclear fuel and remove risks associated with storage and disposal, and to manage the resultant high-level waste in a cost-effective manner. If this alternative were pursued aggressively, the generated high-level waste residual resulting from segregating fissile material from the spent nuclear fuel may require additional high-level waste tankage. This increase in capacity would be covered by the High-Level Tank Farm New Tanks project described in Volume 2 of the EIS.

Capacity discussions for industrial/commercial solid waste and low-level waste under Alternative 3 apply to Alternative 4b(1).

5.14.6 Alternative 4b(2) - Regionalization by Geography (Elsewhere)

Construction phase activities would generate a cumulative total of 50 cubic meters of industrial and commercial solid waste. Overall, waste generation would be lower than all of the SNF management alternatives, with the exceptions of the No Action and Decentralization Alternatives.

5.14.7 Alternative 5a - Centralization at Other DOE Sites

In general, the character of the impacts to materials and waste management would be similar to those under Alternative 4b(2).

5.14.8 Alternative 5b - Centralization at the INEL

In general, the character of the impacts to materials and waste management would be similar to those under Alternative 4b(1).

5.15 Accidents

5.15.1 Introduction

Activities associated with the transportation, receipt, handling, stabilization, and storage of spent nuclear fuel at the INEL involve substantial quantities of radioactive materials and limited quantities of toxic chemicals. Under certain circumstances, the potential exists for accidents involving these materials to occur, which would result in exposure to INEL workers or members of the public, or contamination of the surrounding environment. Accidents can be categorized as follows:

- Abnormal events such as minor spills
- Design-basis events, which a facility is designed to withstand
- Beyond-design-basis events, which a facility is not designed to withstand (but whose consequences it may nevertheless mitigate)

This section summarizes postulated radiological and toxic material accidents in each accident category and describes their estimated consequences to workers, members of the public, and the environment. The scope of this section is limited to accidents within facilities; transportation accidents between facilities are addressed in Section 5.11. [Further information on the accidents summarized in this section, as well as information on other "lower consequence" accidents analyzed, is provided in Slaughterbeck et al. (1995)].

An accident is a series of unexpected or undesirable "initiating" events that lead to a release of radioactive or toxic materials within a facility or to the environment. This analysis defines initiating events that can lead to a spent nuclear fuel-related facility accident in three broad categories: external initiators, internal initiators, and natural phenomena initiators. External initiators (e.g., aircraft crashes, and nearby explosions or toxic material releases) originate outside the facility and can affect the ability of the facility to maintain confinement of radioactive or hazardous material. Internal initiators originate within a facility (e.g., equipment failures or human error) and are usually the result of facility operation. Sabotage and terrorist activities (i.e., intentional human initiators) might be either external or internal initiators. Natural phenomena initiators include weather-related (e.g., floods and tornadoes) and seismic events. This analysis defines initiators in terms of events that cause, directly or indirectly, a release of radioactive or hazardous materials within a facility or to the environment by failure or bypass of confinement.

Tables 5.15-1 through 5.15-4 summarize the radiological results of the analyses described in this section. Section 5.15.2 summarizes historic accidents at the INEL associated with spent nuclear fuel-related activities. Section 5.15.3 describes the methodology used to identify and evaluate potential radiological accidents associated with spent nuclear fuel receipt, handling, storage, and intra-area transportation activities. Sections 5.15.4 and 5.15.5 evaluate the postulated maximum reasonably foreseeable radiological and toxic material accidents, respectively.

5.15.2 Historic Perspective

Many of the actions proposed under the different spent nuclear fuel management alternatives considered in this EIS are continuations or variations of past practices at the INEL. DOE has analyzed consequences to the public from historic INEL accidents in detail and has determined them to be low (DOE 1991).

Consequences of accidents can involve fatalities, injuries, or illness. Fatalities can be prompt (immediate), such as in construction accidents, or latent (delayed), such as cancer caused by radiation exposure. While public comments received in scoping meetings for this EIS included many concerns about potential accidents at the INEL, the historic record demonstrates that DOE facilities, including the INEL, have a very good safety record, particularly in comparison to commercial industries (e.g., agriculture and construction). Figure 5.15-1 shows the rate of worker fatalities at the INEL and other DOE sites (DOE 1993b) compared to national-average rates that the National Safety Council compiled over a 10-year period for various industry groups (NSC 1993) and State of Idaho average rates (Hendrix 1994). While past accident occurrence rates are not necessarily indicative of future rates, the historic record reflects the DOE emphasis on safe operations.

There have been no prompt fatalities and no known latent fatalities to members of the public from accidental releases of radioactive or hazardous materials associated with spent nuclear fuel management activities in the 40-year history of INEL facilities, although some accidents associated

Table 5.15-1. Summary of radiological accidents for worker located 100 meters downwind from the point of release.

Accident Description	Attribute	Alternative 1 No Action	Alternative 2 Decentralization	Alternative 3 1992/1993 Planning Basis	Alternative 4a[a] Regionalization by Fuel Type	Alternative 5a Centralization at Other Sites	Alternative 5b Centralization at the INEL
1. Fuel handling accident, fuel pin breach, venting of noble gases and iodine at HFEF[b]	Consequences[c]	(d)	(d)	(d)	(d)	(d)	(d)
	Adjusted annual frequency	1.0y10-2	1.2y10-2	3.1y10-2	4.8y10-2	8.6y10-2	2.0y10-1
	Adjusted point estimate of risk[e]	(d)	(d)	(d)	(d)	(d)	(d)
2. Uncontrolled chain reaction (criticality) at ICPP[f]	Consequences[c]	3.9y10-5	3.9y10-5	3.9y10-5	3.9y10-5	3.9y10-5	3.9y10-5
	Adjusted annual frequency	1.0y10-3	1.0y10-3	1.0y10-3	1.0y10-3	1.0y10-3	1.0y10-3
	Adjusted point estimate of risk[e]	4.0y10-8	4.0y10-8	4.0y10-8	4.0y10-8	4.0y10-8	4.0y10-8
3. Fuel melting of small number of assemblies at HFEF resulting from seismic event and cell breach	Consequences[c]	2.5y10-4	2.5y10-4	2.5y10-4	2.5y10-4	2.5y10-4	2.5y10-4
	Adjusted annual frequency	1.0y10-5	1.0y10-5	1.0y10-5	1.0y10-5	1.0y10-5	1.0y10-5
	Adjusted point estimate of risk[e]	2.5y10-9	2.5y10-9	2.5y10-9	2.5y10-9	2.5y10-9	2.5y10-9
4. Material release from HFEF resulting from aircraft crash and ensuing fire	Consequences[c]	1.8y10-3	1.8y10-3	1.8y10-3	1.8y10-3	1.8y10-3	1.8y10-3
	Adjusted annual frequency	1.0y10-7[g]	1.0y10-7[g]	1.0y10-7[g]	1.0y10-7[g]	1.0y10-7[g]	1.0y10-7[g]
	Adjusted point estimate of risk[e]	1.8y10-10	1.8y10-10	1.8y10-10	1.8y10-10	1.8y10-10	1.8y10-10
5. Inadvertent nuclear criticality at ICPP[f] CPP-666 during processing	Consequences[c]	(h)	(h)	(h)	(h)	(h)	3.6y10-3
	Adjusted annual frequency	(h)	(h)	(h)	(h)	(h)	1.0y10-3
	Adjusted point estimate of risk[e]	(h)	(h)	(h)	(h)	(h)	3.6y10-6
6. Hydrogen explosion in ICPP[f] CPP-666 dissolver	Consequences[c]	(h)	(h)	(h)	(h)	(h)	(d)
	Adjusted annual frequency	(h)	(h)	(h)	(h)	(h)	(d)
	Adjusted point estimate of risk[e]	(h)	(h)	(h)	(h)	(h)	(d)
7. Inadvertent dissolution of 30-day cooled fuel at ICPP[f] CPP-666	Consequences[c]	(h)	(h)	(h)	(h)	(h)	(d)
	Adjusted annual frequency	(h)	(h)	(h)	(h)	(h)	(d)
	Adjusted point estimate of risk[e]	(h)	(h)	(h)	(h)	(h)	(d)

a. The radiological accident results for Alternative 4b(1), "Regionalization by Geography (INEL)," are conservatively assumed to be the same as those presented for Alternative 5b, as discussed in Section 5.15.4.4. The radiological accident results for Alternative 4b(2), "Regionalization by Geography (Elsewhere)," are identical to those presented for Alternative 5a, as discussed in Section 5.15.4.4.

b. HFEF = Hot Fuel Examination Facility.

c. Consequences are presented in terms of latent fatal cancers based on conservative (95 percentile) meteorological conditions. Consequences are calculated by multiplying the estimated exposure (i.e., dose) by an International Commission on Radiological Protection conversion factor of 4.0 y 10-4 cancer per rem for an adult worker (or 8.0 y 10-4 cancer per rem if the estimated exposure is greater than 20 rem).

d. The safety analysis report utilized for this accident analysis does not provide this information because it was developed prior to DOE Order 5480.23 requiring this information. As demonstrated by the dose to the maximally exposed individual, consequences to the public from Accident 1 could be less than the consequences from Accidents 2 through 4. However, given the high frequency for Accident 1 compared to Accidents 2 through 4, the risk could actually be greater than for Accidents 2 through 4.

e. This attribute is equal to consequences y frequency (events per year). The information is based on conservative (95 percentile) meteorological conditions.

f. ICPP = Idaho Chemical Processing Plant.

g. This frequency is a qualitative bounding estimate for a potential aircraft crash, as discussed in Section 5.15.6.4.

h. Resuming processing at the INEL under this alternative is not considered.

Table 5.15-2. Summary of radiological accidents for individual located at the nearest point of public access within the site boundary.

Accident Description	Attribute	Alternative 1 No Action	Alternative 2 Decentralization	Alternative 3 1992/1993 Planning Basis	Alternative 4aa Regionalization by Fuel Type	Alternative 5a Centralization at Other Sites	Alternative 5b Centralization at the INEL
1. Fuel handling accident, fuel pin breach, venting of noble gases and iodine at HFEFb	Consequencesc	(d)	(d)	(d)	(d)	(d)	(d)
	Adjusted annual frequency	1.0y10-2	1.2y10-2	3.1y10-2	4.8y10-2	8.6y10-2	2.0y10-1
	Adjusted point estimate of riske	(d)	(d)	(d)	(d)	(d)	(d)
2. Uncontrolled chain reaction (criticality) at ICPPf	Consequencesc	7.0y10-7	7.0y10-7	7.0y10-7	7.0y10-7	7.0y10-7	7.0y10-7
	Adjusted annual frequency	1.0y10-3	1.0y10-3	1.0y10-3	1.0y10-3	1.0y10-3	1.0y10-3
	Adjusted point estimate of riske	7.0y10-10	7.0y10-10	7.0y10-10	7.0y10-10	7.0y10-10	7.0y10-10
3. Fuel melting of small number of assemblies at HFEF resulting from seismic event and cell breach	Consequencesc	3.3y10-4	3.3y10-4	3.3y10-4	3.3y10-4	3.3y10-4	3.3y10-4
	Adjusted annual frequency	1.0y10-5	1.0y10-5	1.0y10-5	1.0y10-5	1.0y10-5	1.0y10-5
	Adjusted point estimate of riske	3.3y10-9	3.3y10-9	3.3y10-9	3.3y10-9	3.3y10-9	3.3y10-9
4. Material release from HFEF resulting from aircraft crash and ensuing fire	Consequencesc	1.6y10-4	1.6y10-4	1.6y10-4	1.6y10-4	1.6y10-4	1.6y10-4
	Adjusted annual frequency	1.0y10-7g	1.0y10-7g	1.0y10-7g	1.0y10-7g	1.0y10-7g	1.0y10-7g
	Adjusted point estimate of riske	1.6y10-11	1.6y10-11	1.6y10-11	1.6y10-11	1.6y10-11	1.6y10-11
5. Inadvertent nuclear criticality ICPPf CPP-666 during processing	Consequencesc	(h)	(h)	(h)	(h)	(h)	2.5y10-5
	Adjusted annual frequency	(h)	(h)	(h)	(h)	(h)	1.0y10-3
	Adjusted point estimate of riske	(h)	(h)	(h)	(h)	(h)	2.5y10-8
6. Hydrogen explosion in ICPPf CPP-666 dissolver	Consequencesc	(h)	(h)	(h)	(h)	(h)	(d)
	Adjusted annual	(h)	(h)	(h)			

	frequency				(h)	(h)	(d)
	Adjusted point estimate of riske	(h)	(h)	(h)	(h)	(h)	(d)
7. Inadvertent dissolution of 30-day cooled fuel at ICPPf CPP-666	Consequencesc	(h)	(h)	(h)	(h)	(h)	(d)
	Adjusted annual frequency	(h)	(h)	(h)	(h)	(h)	(d)
	Adjusted point estimate of riske	(h)	(h)	(h)	(h)	(h)	(d)

a. The radiological accident results for Alternative 4b(1), "Regionalization by Geography (INEL)," are conservatively assumed to be the same as those presented for Alternative 5b, as discussed in Section 5.15.4.4. The radiological accident results for Alternative 4b(2), "Regionalization by Geography (Elsewhere)," are identical to those presented for Alternative 5a, as discussed in Section 5.15.4.4.

b. HFEF = Hot Fuel Examination Facility.

c. Consequences are presented in terms of latent fatal cancers based on conservative (95 percentile) meteorological conditions. Consequences are calculated by multiplying the estimated exposure (i.e., dose) by an International Commission on Radiological Protection conversion factor of 5.0 y 10-4 cancer per person-rem for the offsite population (or 1.0 y 10-3 cancer per rem if the estimated population exposure is greater than 20 rem for any individual member of the public).

d. The safety analysis report utilized for this accident analysis does not provide this information because it was developed prior to DOE Order 5480.23 requiring this information. As demonstrated by the dose to the maximally exposed individual, consequences to the public from this accident could be less than the consequences from Accidents 2 through 4. However, given the high frequency for this accident compared to Accidents 2 through 4, the risk could actually be greater than for Accidents 2 through 4.

e. This attribute is equal to consequences y frequency (events per year). The information is based on conservative (95 percentile) meteorological conditions.

f. ICPP = Idaho Chemical Processing Plant.

g. This frequency is a qualitative bounding estimate for a potential aircraft crash, as discussed in Section 5.15.6.4.

h. Resuming processing at the INEL under this alternative is not considered.

Table 5.15-3. Summary of radiological accidents for maximally exposed hypothetical individual located at the nearest site boundary.

Accident Description	Attribute	Alternative 1 No Action	Alternative 2 Decentralization	Alternative 3 1992/1993 Planning Basis	Alternative 4aa Regionalization by Fuel Type	Alternative 5a Centralization at Other Sites	Alternative 5b Centralization at the INEL
1. Fuel handling accident, fuel pin breach, venting of noble gases and iodine at HFEFb	Consequencesc	1.0y10-6	1.0y10-6	1.0y10-6	1.0y10-6	1.0y10-6	1.0y10-6
	Adjusted annual frequency	1.0y10-2	1.2y10-2	3.1y10-2	4.8y10-2	8.6y10-2	2.0y10-1
	Adjusted point estimate of riskd	1.0y10-8	1.2y10-8	3.1y10-8	4.8y10-8	8.6y10-8	2.0y10-7
2. Uncontrolled chain reaction (criticality) at ICPPe	Consequencesc	5.0y10-7	5.0y10-7	5.0y10-7	5.0y10-7	5.0y10-7	5.0y10-7
	Adjusted annual frequency	1.0y10-3	1.0y10-3	1.0y10-3	1.0y10-3	1.0y10-3	1.0y10-3
	Adjusted point estimate of riskd	5.0y10-10	5.0y10-10	5.0y10-10	5.0y10-10	5.0y10-10	5.0y10-10
3. Fuel melting of small number of assemblies at HFEF resulting from seismic event and cell breach	Consequencesc	2.5y10-3	2.5y10-3	2.5y10-3	2.5y10-3	2.5y10-3	2.5y10-3
	Adjusted annual frequency	1.0y10-5	1.0y10-5	1.0y10-5	1.0y10-5	1.0y10-5	1.0y10-5

	Adjusted point estimate of riskd	2.5y10-8	2.5y10-8	2.5y10-8	2.5y10-8	2.5y10-8	2.5y10-8
4. Material release from HFEF resulting from aircraft crash and ensuing fire	Consequencesc	2.5y10-3	2.5y10-3	2.5y10-3	2.5y10-3	2.5y10-3	2.5y10-3
	Adjusted annual frequency	1.0y10-7f	1.0y10-7f	1.0y10-7f	1.0y10-7f	1.0y10-7f	1.0y10-7f
	Adjusted point estimate of riskd	2.5y10-10	2.5y10-10	2.5y10-10	2.5y10-10	2.5y10-10	2.5y10-10
5. Inadvertent nuclear criticality ICPPe CPP-666 during processing	Consequencesc	(g)	(g)	(g)	(g)	(g)	1.4y10-5
	Adjusted annual frequency	(g)	(g)	(g)	(g)	(g)	1.0y10-3
	Adjusted point estimate of riskd	(g)	(g)	(g)	(g)	(g)	1.4y10-8
6. Hydrogen explosion in ICPPe CPP-666 dissolver	Consequencesc	(g)	(g)	(g)	(g)	(g)	3.2y10-7
	Adjusted annual frequency	(g)	(g)	(g)	(g)	(g)	1.0y10-5
	Adjusted point estimate of riskd	(g)	(g)	(g)	(g)	(g)	3.2y10-12
7. Inadvertent dissolution of 30-day cooled fuel at ICPPe CPP-666	Consequencesc	(g)	(g)	(g)	(g)	(g)	1.5y10-5
	Adjusted annual frequency	(g)	(g)	(g)	(g)	(g)	1.0y10-6
	Adjusted point estimate of riskd	(g)	(g)	(g)	(g)	(g)	1.5y10-11

a. The radiological accident results for Alternative 4b(1), "Regionalization by Geography (INEL)," are conservatively assumed to be the same as those presented for Alternative 5b, as discussed in Section 5.15.4.4. The radiological accident results for Alternative 4b(2), "Regionalization by Geography (Elsewhere)," are identical to those presented for Alternative 5a, as discussed in Section 5.15.4.4.
b. HFEF = Hot Fuel Examination Facility.
c. Consequences are presented in terms of latent fatal cancers based on conservative (95 percentile) meteorological conditions. Consequences are calculated by multiplying the estimated exposure (i.e., dose) by an International Commission on Radiological Protection conversion factor of 5.0 y 10-4 cancer per person-rem for the offsite population (or 1.0 y 10-3 cancer per rem if the estimated population exposure is greater than 20 rem for any individual member of the public).
d. This is equal to consequences y frequency (events per year). The information is based on conservative (95 percentile) meteorological conditions.
e. ICPP = Idaho Chemical Processing Plant.
f. This frequency is a qualitative bounding estimate for a potential aircraft crash, as discussed in Section 5.15.6.4.
g. Resuming processing at the INEL under this alternative is not considered.

Table 5.15-4. Summary of radiological accidents for offsite population within 80 kilometers (50 miles) from the point of release.

Accident Description	Attribute	Alternative 1 No Action	Alternative 2 Decentralization	Alternative 3 1992/1993 Planning Basis	Alternative 4aa Regionalization by Fuel Type	Alternative 5a Centralization at Other Sites	Alternative 5b Centralization at the INEL
1. Fuel handling accident, fuel pin breach, venting of noble gases and iodine at HFEFb	Consequencesc	(d)	(d)	(d)	(d)	(d)	(d)
	Adjusted annual frequency	1.0y10-2	1.2y10-2	3.1y10-2	4.8y10-2	8.6y10-2	2.0y10-1
	Adjusted point estimate of riske	(d)	(d)	(d)	(d)	(d)	(d)
2. Uncontrolled chain reaction	Consequencesc	3.0y10-4	3.0y10-4	3.0y10-4	3.0y10-4	3.0y10-4	3.0y10-4

(criticality) at ICPPf							
	Adjusted annual frequency	1.0y10-3	1.0y10-3	1.0y10-3	1.0y10-3	1.0y10-3	1.0y10-3
	Adjusted point estimate of riske	3.0y10-7	3.0y10-7	3.0y10-7	3.0y10-7	3.0y10-7	3.0y10-7
3. Fuel melting of small number of assemblies at HFEF resulting from seismic event and cell breach	Consequencesc	7.0y100	7.0y100	7.0y100	7.0y100	7.0y100	7.0y100
	Adjusted annual frequency	1.0y10-5	1.0y10-5	1.0y10-5	1.0y10-5	1.0y10-5	1.0y10-5
	Adjusted point estimate of riske	7.0y10-5	7.0y10-5	7.0y10-5	7.0y10-5	7.0y10-5	7.0y10-5
4. Material release from HFEF resulting from aircraft crash and ensuing fire	Consequencesc	1.0y100	1.0y100	1.0y100	1.0y100	1.0y100	1.0y100
	Adjusted annual frequency	1.0y10-7g	1.0y10-7g	1.0y10-7g	1.0y10-7g	1.0y10-7g	1.0y10-7g
	Adjusted point estimate of riske	1.0y10-7	1.0y10-7	1.0y10-7	1.0y10-7	1.0y10-7	1.0y10-7
5. Inadvertent nuclear criticality ICPPf CPP-666 during processing	Consequencesc	(h)	(h)	(h)	(h)	(h)	2.8y10-3
	Adjusted annual frequency	(h)	(h)	(h)	(h)	(h)	1.0y10-3
	Adjusted point estimate of riske	(h)	(h)	(h)	(h)	(h)	2.8y10-6
6. Hydrogen explosion in ICPPf CPP-666 dissolver	Consequencesc	(h)	(h)	(h)	(h)	(h)	4.1y10-4
	Adjusted annual frequency	(h)	(h)	(h)	(h)	(h)	1.0y10-5
	Adjusted point estimate of riske	(h)	(h)	(h)	(h)	(h)	4.1y10-9
7. Inadvertent dissolution of 30-day cooled fuel at ICPPf CPP-666	Consequencesc	(h)	(h)	(h)	(h)	(h)	1.5y10-2
	Adjusted annual frequency	(h)	(h)	(h)	(h)	(h)	1.0y10-6
	Adjusted point estimate of riske	(h)	(h)	(h)	(h)	(h)	1.5y10-8

a. The radiological accident results for Alternative 4b(1), "Regionalization by Geography (INEL)," are conservatively assumed to be the same as those presented for Alternative 5b, as discussed in Section 5.15.4.4. The radiological accident results for Alternative 4b(2), "Regionalization by Geography (Elsewhere)," are identical to those presented for Alternative 5a, as discussed in Section 5.15.4.4.

b. HFEF = Hot Fuel Examination Facility.

c. Consequences are presented in terms of latent fatal cancers based on conservative (95 percentile) meteorological conditions. Consequences are calculated by multiplying the estimated exposure (i.e., dose) by an International Commission on Radiological Protection conversion factor of 5.0 y 10-4 cancer per person-rem for the offsite population (or 1.0 y 10-3 cancer per rem if the estimated population exposure is greater than 20 rem for any individual member of the public).

d. The safety analysis report utilized for this accident analysis does not provide this information because it was developed prior to DOE Order 5480.23 requiring this information. As demonstrated by the dose to the maximally exposed individual, consequences to the public from this accident could be less than the consequences from Accidents 2 through 4. However, given the high frequency for this accident compared to Accidents 2 through 4, the risk could actually be greater than for Accidents 2 through 4.

e. This attribute is equal to consequences y frequency (events per year). The information is based on conservative (95 percentile) meteorological conditions.

f. ICPP = Idaho Chemical Processing Plant.

g. This frequency is a qualitative bounding estimate for a potential aircraft crash, as discussed in Section 5.15.6.4.

h. Resuming processing at the INEL under this alternative is not considered.

Figure 5.15-1. Comparison of fatality rates among workers in various industry groups. with spent nuclear fuel management activities have occurred. In 1958, filters in the Idaho Chemical Processing Plant CPP-601 Fuel Element Cutting Facility failed during decontamination operations. An estimated 100 curies of particulate radioactivity were released over an area of approximately 200 acres (0.809 square kilometers) in the vicinity of the Idaho Chemical Processing Plant. Approximately 39 curies became airborne, resulting in an estimated dose of 0.11 millirem to a hypothetical offsite individual located at the nearest site boundary (DOE 1991).

Three inadvertent nuclear chain reactions (i.e., nuclear criticalities) occurred at the Idaho Chemical Processing Plant in 1959, 1961, and 1978. The 1959 criticality occurred in a process waste and cell floor drain collection tank. Available evidence indicates that the critical solution resulted from an accidental transfer of concentrated uranyl nitrate solution to the waste collection tank through a line normally used to transfer decontaminating solutions to the waste tank. The estimated airborne release from this incident was 3,700 curies, and the estimated dose to the maximally exposed hypothetical individual located at the nearest site boundary was 1.1 millirem (DOE 1991). The 1961 and 1978 nuclear criticalities resulted from spent nuclear fuel dissolution and reprocessing activities. Estimated releases to the environment as a result of these accidents were 120 curies and 620 curies for the 1961 and 1978 accidents, respectively, and the calculated radiation doses at the nearest site boundary were less than 0.1 millirem for both releases (DOE 1991).

The INEL Fluorinel and Storage (FAST) facility (CPP-666), which historically performed spent nuclear fuel-related reprocessing activities, is currently shut down. Activities are under way to place this facility in a permanent shutdown mode. Restart of this facility and the potential for an inadvertent nuclear criticality resulting from operating this facility are considered in Sections 5.15.4.4 and 5.15.4.5 [Alternatives 4b(1) and 5b, respectively]. Because DOE has no current plans to resume spent nuclear fuel reprocessing activities at the Idaho Chemical Processing Plant, events similar to the three historic nuclear criticalities discussed above will be unlikely in future INEL spent nuclear fuel-related activities. Additional information regarding the historical accidents summarized above is provided in Slaughterbeck et al. (1995).

In the site's 40-year history, three prompt fatalities of INEL workers have occurred by accidents involving radiation exposure. In 1961, a steam explosion resulting from an unplanned nuclear criticality in an experimental reactor (Stationary Low-Power Reactor No. 1) killed these workers, who were manually moving reactor control elements. The estimated dose from this accident to a hypothetical individual located at the nearest site boundary was approximately 3 millirem (DOE 1991). All the accidents discussed above have caused contamination that has led to secondary impacts, such as the contamination of facility equipment and land inside the site boundary, and have required cleanup.

Twenty workers at the Argonne National Laboratory-West facility area were injured in early 1994 when, in an accident involving toxic material exposure, approximately 9 kilograms (20 pounds) of chlorine gas used to treat potable (i.e., drinking) water were accidently released to the environment. Although an investigation into this incident by the DOE was still ongoing at the time this analysis was performed, the accident is presumed to have occurred while a vendor was removing and replacing a nearly empty chlorine cylinder. A maintenance employee assisting in the activity apparently disconnected the nearly empty in-service chlorine gas cylinder from the potable water system with the cylinder valve in the open position, resulting in the remaining tank contents being discharged to the environment. As a result of the accidental release, 20 workers were sent to a local hospital. Eighteen workers reported for treatment of minor respiratory distress, one worker reported symptoms of more serious respiratory problems, and one worker reported back injuries as a result of falling while responding to the accident. (ANL 1994 and DOE 1994b).

5.15.3 Methodology for Determining the Maximum Reasonably Foreseeable Radiological Accidents

5.15.3.1 Selection of Spent Nuclear Fuel Facilities and Operations Requiring

Accident Analyses. The accident analyses performed to support this EIS considered all INEL nonreactor nuclear facilities that support spent nuclear fuel-related activities with the exception of those at the Naval Reactors Facility (NRF) area. Appendix D of this EIS discusses each of the spent nuclear fuel management alternatives and postulated accident scenarios associated with the Naval Reactors Facility and other naval spent nuclear fuel facilities.

DOE Order 5480.23 (DOE 1992a) defines nonreactor nuclear facilities as those activities or operations that involve radioactive or fissionable materials in such form and quantity that a nuclear hazard potentially exists to the workers or the general public. This analysis considered spent nuclear fuel facilities designed and constructed as direct support to reactor facilities (e.g., Advanced Test Reactor Storage Canal, which stores spent nuclear fuel and irradiated fuels) as nonreactor spent nuclear fuel facilities.

DOE manages spent nuclear fuel at the following INEL facility areas: Idaho Chemical Processing Plant, Naval Reactors Facility, Test Reactor Area, Auxiliary Reactor Area/Power Burst Facility, Argonne National Laboratory-West, and Test Area North. For further information regarding the activities conducted in these areas, refer to Chapter 2. After identifying all the nonreactor nuclear facilities within these facility areas that stabilize, handle, or store spent nuclear fuel, this analysis ranked the facilities according to potential hazards using preexisting facility "hazard classifications." DOE Order 5480.23 requires contractors operating nonreactor nuclear facilities to perform a hazard classification of a facility to assess the consequences of an unmitigated release of radioactive or hazardous material in one of the following categories(1):

- Category 1. The hazard analysis shows the potential for significant offsite consequences.
- Category 2. The hazard analysis shows the potential for significant onsite consequences.
- Category 3. The hazard analysis shows the potential for only significant localized consequences.

The classification of nonreactor nuclear facilities in one of these three categories was in accordance with DOE Standard DOE-STD-1027-92 (DOE 1992b). This standard provides guidance for the hazard categorization of nuclear facilities based on facility inventories of radionuclides and the potential for those radionuclides to affect workers or the public if released to the environment.

This analysis used these categories as a screening threshold to identify those facilities of interest (i.e., those spent nuclear fuel-related facilities with sufficient quantities of radionuclides to present the potential for significant impacts to workers or the public if released to the environment). The analysis excluded (screened out) Category 3 (low hazard) facilities if they present possible worker consequences enveloped by postulated accidents at Category 2 facilities. Facilities with a hazard classification of 2 or greater (or Category 3 facilities that were not screened out) were evaluated further, as discussed in the next section.

5.15.3.2 Determination of Maximum Reasonably Foreseeable Radiological

Accidents. After determining spent nuclear fuel-related facilities with sufficient quantities of radionuclides to present radiological consequences to workers or the public (as discussed in Section 5.15.3.1), the analysis generated potential accident scenarios for each of these INEL facilities by performing the following activities:

- Reviewing historic spent nuclear fuel-related accidents that have occurred during the 40-year history of the INEL.
- Reviewing existing accident analyses and safety analysis reports for spent nuclear fuel-related activities and facilities.

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1. These categories were formerly labeled "high", "moderate," and "low" in accordance with DOE Order 5480.23 for nonreactor nuclear facilities.

- Identifying potential internal, external, and natural phenomena events that could initiate spent nuclear fuel-related accidents other than those previously analyzed.
- Performing additional accident analyses for those accidents considered to present the greatest consequences to workers or the public, as necessary.

The analysis considered internal and external initiators associated with a wide range of activities (e.g., research and development and construction or modification of facilities) not necessarily covered in existing safety analyses. For example, potential radiological accident scenarios initiated by construction activities associated with constructing new spent nuclear fuel-related facilities or modifying existing spent nuclear fuel-related facilities (as proposed under the various alternatives) were postulated. Typically, events involved in the construction of new spent nuclear fuel-related facilities would act as external initiators to existing facilities, while events involved in modifying existing spent nuclear fuel facilities would act as internal initiators. Examples of construction or industrial-type events that could initiate a radiological accident included fires, confinement impacts or puncture events, equipment failure, and human error.

Additional considerations used to determine potential internal and external initiators that could lead to spent nuclear fuel-related radiological accidents included vulnerabilities associated with handling, stabilizing, and storing severely degraded spent nuclear fuel and equipment. For example, in November 1993, DOE issued a report (DOE 1993c) discussing vulnerabilities associated with various spent nuclear fuel-related facilities across the DOE complex. The report identified one INEL facility, the CPP-603 Underwater Fuel Storage Facility, as requiring immediate management attention to avoid unnecessary increases in worker exposures, cleanup costs, and postulated accident frequencies. Activities have begun to stabilize spent nuclear fuel inventories in the CPP-603 facility and relocate them to another facility (CPP-666); these activities will continue for several years after the scheduled 1995 Record of Decision for this EIS. Therefore, the analysis considered postulated accident scenarios associated with stabilizing and relocating CPP-603 spent nuclear fuel inventories to be potential accident initiators in developing the radiological accidents summarized in this EIS. Examples of accident scenarios considered as a result of degraded spent nuclear fuel or facility equipment included inadvertent nuclear criticalities, physical damage of spent nuclear fuel and spent nuclear fuel facilities, and radionuclide releases resulting from handling and stabilizing degraded spent nuclear fuel. For postulated accident scenarios at facilities other than the CPP-603 Underwater Fuel Storage Facility, the analysis also considered the potential for long-term degradation of facility structures, equipment, and spent nuclear fuel inventories that could lead to an increased probability for radiological accidents.

To compare the various possible spent nuclear fuel-related accident scenarios and to identify those maximum reasonably foreseeable accidents that present the greatest consequences to workers and the public, the analysis divided each postulated spent nuclear fuel-related accident into the appropriate frequency category (abnormal events, design-basis accidents(2), or beyond-design-basis accidents), according to its estimated frequency of occurrence. Table 5.15-5 lists the frequency ranges associated with the abnormal event, design-basis accident, and beyond-design-basis accident categories discussed in Section 5.15.1.

The estimated frequency of each postulated accident was based on an identification of the physical basis for the accident and the events required for the accident to occur. Because many of the postulated accidents or their constituent events (initiators or precursors) have rarely or never occurred, frequency data based on historic experience were not available. Therefore, in many instances, it was necessary to develop a frequency estimate on the basis of events for which experience existed and engineering judgment. More than 40 sources of frequency data for the accident events postulated were reviewed, including analyses and reports prepared for the DOE, U.S. Nuclear Regulatory Commission (NRC), Electric Power Research Institute, and private industry. [For further information regarding the development of estimated accident frequencies, refer to Slaughterbeck et al. (1995).]

After the division of the postulated spent nuclear fuel-related accidents into the frequency ranges defined in Table 5.15-5, the analysis identified the postulated nonprocessing-related accident within each frequency range determined to present the maximum offsite consequences as a maximum reasonably foreseeable radiological accident to be further analyzed for this EIS. Potential nonprocessing-related accident scenarios were chosen as maximum reasonably foreseeable accidents because of the shutdown status of the INEL facility (CPP-666) that historically processed spent nuclear fuel. However, because existing inventories of spent nuclear fuel at the INEL would substantially increase under Alternatives 4b(1) and 5b [Regionalization by Geography (INEL) and Centralization at the INEL, respectively], there could be a need to resume processing operations to stabilize degraded spent nuclear fuel operations and assure adequate storage space for spent nuclear fuel received from other sites(3). Therefore, in addition to the maximum reasonably foreseeable nonprocessing-related accident scenarios, this analysis considers the three postulated processing-related accidents that present the maximum offsite consequences as additional maximum reasonably foreseeable accidents under Alternatives 4b(1) and 5b.

Table 5.15-5. Accident frequency categories.

Frequency Category	Accident Frequency Range (accidents per year)
Abnormal events	frequency > 1y10-3 per year
Design-basis accidents	1y10-3 per year > frequency > 1y10-6 per year
Beyond-design-basis accidents	1y10-6 per year > frequency > 1y10-7 per year

In addition, a postulated inadvertent nuclear criticality accident at the CPP-603 Underwater Storage Facility was considered for further analysis because significant vulnerabilities associated with its spent nuclear fuel inventories have been identified (DOE 1993b) and postulated criticality accidents have been addressed in virtually all nonreactor DOE EISs and safety analysis reports where the accidents are reasonably foreseeable because of public concerns regarding their potential. As a result, the seven radiological accidents summarized in Section 5.15.4 were determined to be the maximum reasonably foreseeable radiological accidents (i.e., greatest consequences). Further discussion and analysis information for each of these accidents, as well as other accidents analyzed, is provided in Slaughterbeck et al. (1995). Appendix D identifies maximum reasonably foreseeable accidents associated with transporting, receiving, handling, and storing naval spent nuclear fuel at the INEL.

The postulated accidents summarized in this section considered with the INEL facilities analyzed in Appendix D provide a basis for characterizing the potential risks and consequences associated with managing spent nuclear fuel at the INEL over the next 40 years.

Seismic events were the only identified common-cause initiators with the potential to initiate radioactive material releases to the environment at more than one spent nuclear fuel-related facility at the INEL. However, a seismic event resulting in significant damage and radioactive releases from facilities in more than one facility area (e.g., Idaho Chemical Processing Plant and Test Area North) is considered beyond reasonably foreseeable (frequency less than one in ten million years), because of the physical distance and isolation between facility areas. In accordance with DOE guidance (DOE 1994a), a seismic event initiating multiple-facility releases in more than one facility area on the site was screened from further consideration because of its extremely low frequency of occurrence.

Analyses were performed that evaluated the potential consequences and risks associated with multiple-facility releases within a single INEL facility area resulting from a severe seismic event

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2. For facilities where design-basis accident analyses were unavailable, evaluation basis accident scenarios (postulated accident scenarios used where documented design basis accident analyses do not exist) were considered in accordance with DOE-DP-STD-3005-YR (DOE 1994a).

3. Processing would be performed in the Flourinel and Storage (FAST) facility (CPP-666) and a new facility to be constructed, the Fuel Processing Restoration (FPR) facility (CPP-691). Processing would consist of dissolving spent nuclear fuel to immobilize radionuclides for final waste disposal.

(Slaughterbeck et al. 1995). For example, within a 500-meter radius in the Idaho Chemical Processing Plant facility area, there are several spent nuclear fuel facilities, the primary facilities being the CPP-749 dry storage facilities and the CPP-666 and CPP-603 underwater fuel storage facilities. An analysis was performed (Slaughterbeck et al. 1995) to determine whether simultaneous releases from these facilities could result from a severe seismic event. Because the CPP-666 and CPP-749 facilities were designed and qualified to withstand a severe seismic event, they are not expected to contribute to the consequences and risks resulting from a severe seismic event impacting the Idaho Chemical Processing Plant. However, because of known structural deficiencies and vulnerabilities with the spent nuclear fuel at the CPP-603 facility, the CPP-603 facility is expected to be significantly damaged following a severe seismic event, resulting in one or more criticalities and the leakage of contaminated basin water to the surrounding environment. While the consequences from these simultaneous multiple-release mechanisms (one or more criticalities and water drainage) would be greater than the single criticality analyzed for CPP-603 facility (Section 5.15.3.3.2), the consequences and risk of such releases are expected to be bounded by the other accidents analyzed in the EIS--primarily, a seismic event that causes fuel melting at the Argonne National Laboratory-West Hot Fuel Examination Facility (highest consequence accident), and a fuel handling accident in the same facility (highest risk accident, where risk = consequence x frequency). Similar analyses (DOE 1993a) for the Test Area North and Argonne National Laboratory-West also demonstrate that potential multiple-facility releases or multiple-release mechanisms from a single facility resulting from a severe seismic event would also be bounded by accidents postulated for the Hot Fuel Examination Facility. Based on this conclusion and the accident selection methodology described 5.15.3.1, the consequences and risks associated with multiple-facility releases were screened from further consideration since they do not represent the bounding accident scenarios within the frequency categories defined in Table 5.15-5.

In addition, the screening methodology did not specifically include potential accident scenarios associated with operating new spent nuclear fuel handling and storage facilities proposed under the various alternatives considered in this EIS because postulated accident scenarios for existing facilities would bound the consequences associated with potential accidents at new facilities. This assumption is appropriate for two primary reasons. First, the missions of new spent nuclear fuel facilities would be similar to the missions of existing spent nuclear fuel-related DOE facilities, which implies that DOE would consider the same types of accident scenarios for the new facilities it considered for the existing facilities. Second, DOE would design and build new facilities that would incorporate modern preventive and mitigative features to reduce the frequency and potential consequences associated with postulated accidents.

To compare the consequences of the same accident scenario at an identical hypothetical facility constructed at each DOE site included in this EIS (based on local geological and meteorological conditions), Appendix D summarizes postulated accident scenarios for a new Expended Core Facility at Oak Ridge, Hanford Site, Savannah River Site, or Nevada Test Site.

To determine the radiological and toxicological consequences presented throughout Section 5.15 associated with the postulated accidents and with spent nuclear fuel-related activities, the analysis used the following definitions:

- Worker. An individual 100 meters (328 feet) downwind of the facility location where the release occurs.[4]
- Nearest Public Access. The nearest point of public access to the location where the release occurs, sometimes inside the site boundary.

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[4] The worker is defined as the individual located at 100 meters because reliable safety analyses quantifying the impacts (e.g., dose and health effects) to workers at distances less than 100 (i.e., "close-in" workers) meters fram an accidental release of radionuclides are unavailable. The effects on and risks to workers closer in than 100 meters are recognized and discussed in Section 5.15.3.3. Each of the maximum reasonably forseeable accidents considered in this EIS, particularly the design-basis and beyond-design-basis accidents, contains some risk of worker

injury or death at distances closer than 100 meters.

- Maximally Exposed Offsite Individual. A hypothetical resident at the site boundary nearest to the facility where the release occurs.
- Offsite Population. The collective total of individuals within an 80-kilometer (50-mile) radius of the INEL.
- Environment. The area outward from 100 meters (328 feet) downwind of the facility where the release occurs.

5.15.3.3 Impact of Accidents on Close-In Workers. An evaluation has been made on the

radiological impact to close-in workers from the selected accident scenarios. Injuries or fatalities that might occur due to an external event, such as a severe seismic disturbance or airplane crash into the structure, are not considered in this evaluation since they are not attributable to direct radiological consequences. Seven accident scenarios for nonprocessing-related and processing-related activities are considered maximum reasonably foreseeable accidents.

5.15.3.3.1 Mechanical Handling Accident at the Argonne National Laboratory

West Hot Fuel Examination Facility - This accident is assumed to result in fuel pin breach and venting of noble gases and iodine. No fatalities to workers are expected from this event. However, a substantial iodine dose to the thyroid could cause radiation-induced hypothyroidism or a similar disorder.

5.15.3.3.2 Criticality Accident at the Idaho Chemical Processing Plant -

CPP-603 - This event is an unplanned nuclear criticality associated with underwater spent nuclear fuel storage at the CPP-603 facility. Based on shielding provided by the pool water, it is likely that no fatalities would occur. To the extent water is expelled due to the energy of the event, close-in workers could receive substantial radiation exposure. Worker presence in the area above the pool or very close to the edge of the pool is not routine. The impact of the event would likely be isolated to nearby equipment operators if the criticality were initiated by a handling error.

5.15.3.3.3 Seismic Event Leading to Fuel Melt at the Argonne National

Laboratory West Hot Fuel Examination Facility - A seismic event is postulated to result in a breech of the main cell used for examination of the fuel, which is assumed to lead to a failure of the fuel cooling system. It is likely that the release of radioactive materials from fuel melting would occur slowly enough to allow evacuation of all workers before any appreciable exposure. Therefore, no radiation-induced fatalities would be expected.

5.15.3.3.4 Airplane Crash and Fire at Argonne National Laboratory West Hot

Fuel Examination Facility - An airplane crash and subsequent fire sustained by airplane fuel could result in a major breach of the confinement barriers and could lead to a substantial atmospheric release of radionuclides. Workers unaffected by the airplane crash or fire would not be expected to remain in the area long enough to receive substantial radiation exposure. It is assumed the buoyancy of the radioactive material due to the fire would mitigate the direct radiological impacts to close-in workers, substantially reducing the likelihood of radiation induced worker fatalities.

5.15.3.3.5 Criticality Accident During Processing at the Idaho Chemical

Processing Plant - CPP-666 - This is the first of three evaluated accidents that could occur only if processing were resumed at the Fluorinel and Storage Facility (FAST). Three inadvertent nuclear criticalities have occurred in INEL processing facilities and none has resulted in worker fatalities. In each event, radioactive material was released to the atmosphere and close-in workers received direct exposure. If processing were resumed, the techniques and controls implemented to prevent recurrence of processing-related criticalities would be employed again. Due to the cell wall shielding provided by concrete walls that are several feet thick, it is expected that no workers would receive substantial radiation exposure.

5.15.3.3.6 Hydrogen Explosion at the Idaho Chemical Processing Plant - A

hydrogen explosion in the dissolver off-gas system of the Flourinel and Storage (FAST) Facility would result in release of radioactive material to the facility. If workers were near the dissolver off-gas system, they could receive substantial radiation exposure from the explosion. No fatalities would be expected, but radiation-induced health detriments could occur.

5.15.3.3.7 Dissolution of Short-Cooled Fuel at the Idaho Chemical Processing

Plant - An explosion in the dissolver tank could occur if fuel that has not cooled for at least 30 days was inadvertently shipped to the dissolver at the Flourinel and Storage Facility (FAST). This energetic event would likely breach the dissolver off gas system and could breach the dissolver tank. Workers in the areas closely associated with the dissolver tank could receive substantial radiation exposure, but it is likely that no radiation-induced fatalities would occur.

5.15.3.4 Analysis of Radiological Accident Consequences. The quantities of

radioactive materials and the ways these materials interact with human beings are important factors in determining health effects. The ways in which radioactive materials reach human beings, their absorption and retention in the body, and the resulting health effects have been studied in great detail. The International Commission on Radiological Protection (ICRP) has made specific recommendations for quantifying these health effects (ICRP 1991). This organization is the recognized body for establishing standards for the protection of workers and the public from the effects of radiation exposure. Health effects can be classified into two categories: prompt (also referred to as acute) and latent. Prompt health effects are those experienced immediately after exposure and include damage to the body up to and including death. Latent health effects are those experienced some time after exposure and include cancers and hereditary symptoms. An INEL-developed computer code, Radiological Safety Analysis Computer Program-5 (RSAC-5), estimates potential radiation doses to maximally exposed individuals or population groups from accidental releases of radionuclides. This code, which is customized to specific INEL conditions, uses well-established and generally accepted scientific engineering principles as the basis for its various calculational steps. The code is based on guidance provided in NRC Guide 1.145 (NRC 1983) and has been validated to comply with accepted standards for such software. [For a detailed description of RSAC-5, refer to Slaughterbeck et al.

(1995).]

The RSAC-5 code determined estimated consequences to the worker, an individual assumed to be stranded at the nearest point of public access, the maximally exposed hypothetical individual at the nearest site boundary, and the offsite population within 80 kilometers (50 miles) of the radiological accidents postulated under Alternative 1, No Action. Postulated frequencies and consequences analyzed under Alternative 1 are based on (1) the approximate amount of spent nuclear fuel currently at the INEL [measured in Metric Tons Heavy Metal (MTHM)], (2) the estimated increases in inventories resulting from spent nuclear fuel generated by operating INEL reactors (i.e., fuel recently removed from a reactor that has not had sufficient time to cool), and (3) the estimated number of fuel handling activities associated with stabilizing or relocating spent fuel inventories inside the INEL site boundary. Although the four nonprocessing-related maximum reasonably foreseeable radiological accident scenarios identified for Alternative 1 are also considered under Alternatives 2 through 5, proposed changes in INEL spent nuclear fuel inventories and the number of fuel handling activities associated with these changes could affect the estimated frequencies and consequences expected for Alternatives 2 through 5. Therefore, to reasonably estimate the frequencies and consequences associated with activities proposed under Alternatives 2 through 5, the frequencies and consequences for the accidents presented under Alternative 1 require appropriate "adjustment" or "scaling."

To be conservative, the analysis assumed that the increase in the annual frequency of mechanical handling accidents would be equal to the estimated increase in the annual number of handling events proposed under Alternatives 2 through 5. However, the consequences associated with a mechanical handling accident would not vary with a change in the number of handling events because the amount of material involved in each event would not change. To determine potential changes in annual mechanical handling accident frequencies between the different spent nuclear fuel management alternatives, the analysis based its estimates of the annual number of fuel handling events under each alternative on spent fuel shipment rates anticipated for the next 40 years, as discussed in Appendix I.

Estimates of long-term (40-year) and short-term (5-year) shipments at the INEL were considered in determining the annual shipment rates for each alternative. The basis for the number of long-term shipments include spent nuclear fuel the INEL will continue to receive from operating reactors such as DOE, Naval Nuclear Propulsion Program, university, and research reactors. Short-term shipments consist of shipments that would be required to relocate existing spent fuel inventories between sites under the various alternatives. Table 5.15-6 summarizes the estimated annual shipment rate to and from the INEL under each alternative, and within INEL site boundaries. The estimates provided in Table 5.15-6 consider both onsite and offsite shipments.

Table 5.15-6. Determination of accident frequency adjustment factors for Alternatives 2 through 5 based on estimated number of annual spent nuclear fuel shipments under each alternative.

Alternative	Estimated Shipment Rate (per year)a	Adjustment Factor (shipment rate/baseline)
1. No Action	41	Baseline
2. Decentralization	50	1.2
3. 1992/1993 Planning Basis	128	3.1
4a. Regionalization by Fuel Type	195	4.8
4b(1) Regionalization by Geography (INEL)	824	20.0
4b(2) Regionalization by Geography (Elsewhere)	351	8.6
5a. Centralization at Other DOE Sites	351	8.6
5b. Centralization at the INEL	824	20.0

a. Data presented for the estimated annual shipment rate is based on information tabulated in Appendix I. The annual shipment rate for the No-Action Alternative (baseline) is derived from Table 3 of Wichmann 1994.

Based on the number of annual shipments estimated for Alternatives 2 through 5, as listed in Table 5.15-6, the analysis calculated multiplication factors by dividing the estimated shipment rates **under Alternatives 2 through 5 by the baseline (Alternative 1) shipment rate.** To determine the estimated frequency for the maximum reasonably foreseeable mechanical handling accidents under each alternative, the frequency identified for Alternative 1 was multiplied by the appropriate adjustment factor. The same approach determined estimated frequencies for Accident 1 (fuel pin breach and noble gases and iodine release from the Hot Fuel Examination Facility) under Alternatives 2 through 5. For Accident 2 (inadvertent criticality in the CPP-603 Underwater Fuel

Storage Facility resulting from a handling accident associated with degraded spent nuclear fuel), the estimated frequency considered under Alternative 1 (1 y 10-3 event per year) is based on the number of handling activities associated with relocation of the CPP-603 spent nuclear fuel inventories to the CPP-666 facility. Because proposed changes in INEL inventories under the different alternatives would not affect handling events associated with relocating spent fuel from the CPP-603 facility to the CPP-666 facility, the estimated frequency for this mechanical handling event would not change. As a result of this approach and the fact that 3 of the 4 accident scenarios that present the greatest consequences are not handling accidents, Accident 1 is the only accident requiring "adjustment" for each alternative.

Variable source-term-sensitive accidents would have consequences that depended on the amount of spent nuclear fuel in storage. One example is the accidental drainage of a spent fuel storage canal that results in the release of corrosion products in the canal to the environment. The larger the spent fuel inventory in the canal, the larger the release of corrosion products to the environment resulting from draining the canal. (Drainage of a water canal completely filled with spent nuclear fuel was considered in the determination of the maximum reasonably foreseeable accidents and was determined to present lower consequences than other accident scenarios analyzed.) Variable source-term sensitive accidents depend only on spent nuclear fuel inventories and do not require adjustment of their estimated frequencies of occurrence. Because none of the postulated accidents summarized under Alternative 1 is source-term sensitive (e.g., spent nuclear fuel inventories in the Hot Fuel Examination Facility are not likely to increase), adjustment of the estimated consequences calculated under Alternative 1 is not required for Alternatives 2 through 5.

5.15.4 Impacts from Postulated Maximum Reasonably Foreseeable Radiological Accidents

Section 5.15.4.1 summarizes impacts (e.g., exposures and health effects) from the four nonprocessing-related maximum reasonably foreseeable radiological accidents postulated under Alternative 1 (No Action). Sections 5.15.4.4.2.1 through 5.15.4.5.2 describe changes in these postulated accident impacts resulting from changes in spent nuclear fuel inventories and handling activities under the other alternatives. Sections 5.15.4.4.2.1 and 5.15.4.5.2 also summarize impacts from three additional maximum reasonably foreseeable accidents associated with resumption of processing activities at the INEL. Section 5.15.6 provides more information about the assumptions and analyses performed for each of the radiological accidents discussed under each alternative.

5.15.4.1 Alternative 1: No Action. Based on the quantity of spent nuclear fuel at the INEL

(excluding naval fuel at Naval Reactors Facility, which is analyzed in Appendix D), its storage configuration (wet versus dry), the amount of time the spent fuel has been allowed to cool, and consideration of various internal, external, and natural phenomena initiators (as discussed in Section 5.15.3), the postulated accidents listed in Table 5.15-7 would have the greatest radiological consequences within the abnormal event, design-basis accident, and beyond-design-accident categories under this alternative. For each accident, Table 5.15-7 also lists estimated accident frequencies; radiation exposures to the offsite population within 80 kilometers (50 miles), a member of the public stranded at the nearest point of public access inside the INEL site boundary, a hypothetical maximally exposed individual (MEI) at the nearest site boundary, and a worker; point estimates of the annualized risk of the maximally exposed individual contracting a fatal cancer during his/her lifetime as a result of the radiation exposure; and point estimates of risk of the expected number of fatal cancers (annualized and total) in the offsite population. The estimates of the consequences and risk to the offsite population are based on conservative (95 percentile) and average (50 percentile) meteorological conditions(5). The estimates of the consequences and risk to the maximally exposed individual are based on conservative (95 percentile) meteorological conditions. The postulated accidents listed in Table 5.15-7, in conjunction with the maximum reasonably foreseeable spent nuclear fuel accidents identified for the INEL Naval Reactors Facility in Appendix D, characterize the potential consequences and risks associated with the proposed spent fuel management activities at the INEL under this alternative.

Atmospheric transport of radionuclides from the postulated accidents could result in some **secondary impacts, such as contamination of the environment or impacts to national defense.** To

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5. Conservative (95 percentile) meteorological conditions are defined as the meteorlogical conditions that, for a given release, the concentration at a fixed receptor location will not be exceeded 95 percent of the time. Average (50 percentile) meteorological conditions are defined as the meteorological conditions that, for a given release, the concentration at a fixed receptor location will not be exceeded 50 percent of the time.

Table 5.15-7. Impacts from selected maximum reasonably foreseeable radiological accidents - Alternative 1, No Action (50 and 95 percentile meteorological conditions).

Accident	Frequency (events per year)	Worker Dosea (rem)	Nearest Public Accessb (rem)	Dose to MEIc (rem)	Offsite Population Dose (95%) (person-rem)	Point estimates of risk of fatal cancers (per year)		
						MEI	Offsite Population	
						95%d	50%	95%
1. Fuel handling accident, fuel pin breach, venting of noble gases and iodine at HFEFe	1.0y10-2	(f)	(f)	2.0y10-3	(f)	1.0y10-8	(f)	(f)
2. Inadvertent criticality in ICPPg CPP-603 storage facilityh	1.0y10-3	9.7y10-2	1.4y10-3	1.0y10-3	5.9y10-1	5.0y10-10	6.5y10-9 (6.5y10-6)d	3.0y10-7 (3.0y10-4)d
3. Fuel melting of small number of assemblies at HFEF resulting from seismic event and cell breach	1.0y10-5	6.2y10-1	6.5y10-1	5.0y100	1.4y104	2.5y10-8	4.5y10-7 (4.5y10-2)d	7.0y10-5 (7.0y100)d
4. Material release from HFEF resulting from aircraft crash and ensuing fire	1.0y10-7(i)	4.6y100	3.2y10-1	5.0y100	2.0y103	2.5y10-10	3.6y10-8 (3.6y10-1)d	1.0y10-7 (1.0y100)d

a. A worker is defined as a worker located 100 meters (328 feet) from the point of release.
b. Public individual assumed to be stranded at the nearest point of public access inside the site boundary.
c. MEI = Maximally exposed hypothetical offsite individual, located at the nearest site boundary.
d. Maximally exposed individual and offsite population fatal cancer risk = dose y accident frequency y 5.0 y 10-4 fatal cancer per rem (ICRP-60 conversion factor) if dose is less than 20 rem. For doses 20 rem or more the ICRP-60 conversion factor is doubled, or 1.0 y 10-3. Numbers in parentheses indicate the total number of fatal cancers in the population if the accident occurred.
e. HFEF - Hot Fuel Examination Facility.
f. The safety analysis report utilized for this accident analysis does not provide this information because it was developed prior to DOE Order 5480.23 requiring this information. As demonstrated by the dose to the maximally exposed individual, consequences to the public from this accident could be less than the consequences from Accidents 2 through 4.
g. ICPP = Idaho Chemical Processing Plant.
h. Although three nuclear criticalities associated with spent nuclear fuel reprocessing activities have occurred at the INEL during its 40-year operating history, the estimated frequency for an inadvertent criticality is not based on historic reprocessing data because reprocessing is not considered under this alternative. Nominal frequency estimates vary from 1.0 y 10-4 (CPP-666 underwater storage facility) to 1.0 y 10-3 (CPP-603

underwater storage facility) event per year.

i. This frequency is a qualitative bounding estimate for a potential aircraft crash, as discussed in Section 5.15.6.4.

prevent these radionuclides from increasing any potential safety concerns, DOE would initiate cleanup activities if an accident occurred, and no irreversible environmental impacts would be likely. Table 5.15-8 summarizes postulated secondary impacts resulting from the postulated radiological accidents listed in Table 5.15-7.

This analysis takes limited credit for emergency response actions in determining the consequences **listed in Table 5.15-7.** DOE would initiate INEL emergency response programs, as appropriate, following the occurrence of an accident to prevent or mitigate potential consequences. These emergency response programs, implemented in accordance with 5500-DOE series Orders, typically involve emergency planning, emergency preparedness, and emergency response actions. Each emergency response plan utilizes resources specifically dedicated to assist a facility in emergency management. These resources include but are not limited to the following:

- INEL Warning Communications Center
- INEL Fire Department
- Facility Emergency Command Centers
- DOE Emergency Operations Centers
- County and State Emergency Command Centers
- Medical, health physics, and industrial hygiene specialists
- Protective clothing and equipment (respirators, breathing air supplies, etc.)
- Periodic training exercises and drills within and between the organizations involved in implementing the response plans

5.15.4.2 Alternative 2: Decentralization. Adjustments in estimated accident frequencies

and point estimates of risk presented for Alternative 1 would be related to (1) the receipt, handling, and storage activities associated with the additional spent nuclear fuel inventories; and (2) the increase in overall spent nuclear fuel-related storage, relocation, and handling activities not allowed under Alternative 1. Because no changes in the accident consequences estimated for Alternative 1 are likely to occur under this alternative from increased fuel inventories (i.e., the same amount of radioactive material would accidentally be released to the environment as discussed in Section 5.15.3.3), no changes are likely in the postulated secondary impacts listed in Table 5-15-8. Table 5.15-9 summarizes the four postulated accidents with the greatest radiological impacts under this alternative.

Table 5.15-8. Estimated secondary impacts resulting from the maximum reasonably foreseeable accidents postulated under Alternative 1, No Action, assuming conservative (95 percentile) meteorological conditions.

Radiological Accident Summary	Environmental or Social Impacts (Assuming 88 millirem per year limit with 24-hour-per-day exposure)a							
	Biotic Resources	Water Resources	Economic Impacts	National Defense	Environmental Contamination	Endangered Species	Land Use	Treaty Rights & Tribal Resources
1. Fuel handling accident, fuel pin breach, venting of noble gases and iodine at HFEFb (1x10-2 per year)	Limited adverse effects expected to vegetation or wildlife.	Limited adverse effects expected to surface water or groundwater.	Limited economic impacts expected. Any cleanup required would be localized and could be accomplished with existing workforce and equipment.	No effects on national defense expected.	Local contamination requiring cleanup expected around site accident.	No impacts exptected to endangered or threatened species.	No change in land use or irreversible impacts expected.	No irreversible impacts to Native Americans or public lands expected.
2. Uncontrolled chain reaction (criticality) at ICPPc (1x10-3	Limited adverse effects expected to vegetation or wildlife.	Limited adverse effects expected to surface water or groundwater.	No economic impacts expected. Any cleanup required would be	No effects on national defense expected.	Local contamination requiring cleanup expected around	No impacts exptected to endangered or threatened species.	No change in land use or irreversible impacts expected.	No irreversible impacts to Native American or public lands

per year)			localized and could be accomplished with existing workforce and equipment.		site accident.			expected.
3. Fuel melting of small number of assemblies at HFEF resulting from seismic event and cell breach (1x10-5 per year)	Limited adverse effects expected to vegetation or wildlife.	Limited adverse effects expected to surface water or groundwater.	Potential interdiction of affected agricultural products on nearby lands. Local cleanup in the vicinity of HFEF.	No effects on national defense expected.	Local contamination requiring cleanup expected around site accident (on and off the INEL site).	No impacts exptected to endangered or threatened species.	Potential for 1 year of agricultural land withdrawal of up to 10,000 acresd	Potential for temporary restricted access to affected public land (less than 10,000 acres).d
4. Material release from HFEF resulting from aircraft crash and ensuing fire (1x10-7 per year)	Limited adverse effects expected to vegetation or wildlife.	Limited adverse effects expected to surface water or groundwater.	Potential interdiction of affected agricultural products on nearby lands. Local cleanup in the vicinity of HFEF.	No effects on national defense expected.	Local contamination requiring cleanup expected around site accident (on and off the INEL site).	No impacts exptected to endangered or threatened species.	Potential for 1 year of agricultural withdrawal of up to 10,000 acresd	Potential for temporary restricted access to affected public land (less than 10,000 acres).d

a. Postulated secondary impacts based on 10-microrem-per-hour exposure (88 millirem per year with 24-hour-per-day exposure) from ground contamination resulting from radionuclide deposition from the plume. This approach in estimated secondary impacts is conservative because DOE Order 5400.5 states that the public dose limit for exposure to residual contamination and natural background radiation is 100 millirem per year.

b. HFEF = Hot Fuel Examination Facility.

c. ICPP = Idaho Chemical Processing Plant.

d. To convert acres to square kilometers, multiply by 0.004.

Table 5.15-9. Impacts from selected maximum reasonably foreseeable accidents - Alternative 2, Decentralization (50 and 95 percentile meteorological conditions).

Accident	Adjusted Frequencya (events per year)	Worker Doseb (rem)	Nearest Public Accessc (rem)	Dose to MEId (rem)	Offsite Population Dose (95%) (person-rem)	Adjusted point estimates of risk of fatal cancers (per year)		
						MEI	Offsite	Population
						95%e	50%	95%
1. Fuel handling accident, fuel pin breach, venting of noble gas and iodine at HFEFf	1.2y10-2 (1.2)	(g)	(g)	2.0y10-3	(g)	1.2y10-8	(g)	(g)
2. Inadvertent criticality in ICPPh CPP-603 storage facilityi	1.0y10-3 (1.0)j	9.7y10-2	1.4y10-3	1.0y10-3	5.9y10-1	5.0y10-10	6.5y10-9 (6.5y10-6)e	3.0y10-7 (3.0y10-4)e
3. Fuel melting of small number of assemblies at HFEF resulting fr seismic event and ce breach	1.0y10-5 (1.0)	6.2y10-1	6.5y10-1	5.0y100	1.4y104	2.5y10-8	4.5y10-7 (4.5y10-2)e	7.0y10-5 (7.0y100)e
4. Material release from HFEF resulting from	1.0y10-7(k)	4.6y100	3.2y10-1	5.0y100	2.0y103	2.5y10-10	3.6y10-8	1.0y10-7

aircraft crash and (1.0)
(3.6y10-1)e (1.0y100)e
ensuing fire

a. Numbers in parentheses indicate multiplication factor used to scale or adjust estimated accident frequencies under Alternative 1, as described in Section 5.15.3.3.

b. A worker is defined as a worker located 100 meters (328 feet) from the point of release.

c. Public individual assumed to be stranded at the nearest point of public access inside the site boundary.

d. MEI = Maximally exposed hypothetical offsite individual located at the nearest site boundary.

e. Maximally exposed individual and offsite population fatal cancer risk = dose y accident frequency y 5.0 y 10-4 fatal cancer per rem (ICRP-60 conversion factor) if dose is less than 20 rem. For doses of 20 rem or more, the ICRP-60 conversion factor is doubled, or 1.0 y 10-3. Numbers in parentheses indicate total number of fatal cancers in the population if the accident occurs.

f. HFEF = Hot Fuel Examination Facility.

g. The safety analysis report utilized for this accident analysis does not provide this information because it was developed prior to DOE Order 5480.23 requiring this information. As demonstrated by the dose to the maximally exposed individual, consequences to the public from this accident could be less than the consequences from Accidents 2 through 4.

h. ICPP = Idaho Chemical Processing Plant.

i. Although three nuclear criticalities associated with spent nuclear fuel reprocessing activities have occurred at the INEL during its 40-year operating history, the estimated frequency for an inadvertent criticality is not based on historic reprocessing data since reprocessing is not considered under this alternative. Nominal frequency estimates vary from 1.0 y 10-4 (CPP-666 underwater storage facility) to 1.0 y 10-3 (CPP-603 underwater storage facility) events per year.

j. Refer to Sections 5.15.3.3 and 5.15.6.2 for details on why this frequency was not adjusted under this alternative.

k. This frequency is a qualitative bounding estimate for a potential aircraft crash, as discussed in Section 5.15.6.4.

5.15.4.3 Alternative 3: 1992/1993 Planning Basis. Under this alternative, the INEL could receive the following spent nuclear fuel:

- Spent nuclear fuel from domestic DOE and university reactors and foreign research test reactors
- All Training Reactor Isotopics General Atomics (TRIGA) spent nuclear fuel from foreign and Hanford reactors
- Fort St. Vrain spent nuclear fuel from Public Service Company of Colorado
- Special case commercial pressurized water reactor and boiling water reactor spent nuclear fuel from West Valley, New York
- Naval spent nuclear fuel from sites such as the Norfolk or Puget Sound Naval Shipyard.

Adjustments in estimated accident frequencies and point estimates of risk presented for Alternative 1 would be related to (1) the receipt, handling, and storage activities associated with the additional spent nuclear fuel inventories; and (2) the increase in overall spent fuel-related storage, relocation, and handling activities not allowed under Alternative 1. Because no changes in the accident consequences estimated for Alternative 1 are likely to occur under this alternative from increased fuel inventories (i.e., the same amount of radioactive material would accidentally be released to the environment as discussed in Section 5.15.3.3), no changes are likely in the postulated secondary impacts listed in Table 5.15-8. Table 5.15-10 summarizes the postulated accidents with the greatest radiological impacts under this alternative.

5.15.4.4 Alternative 4: Regionalization. Under this alternative, there are two primary Regionalization alternatives: (1) Alternative 4a (Regionalization by Fuel Type), where existing and spent nuclear fuel inventories will be distributed between the DOE sites based primarily on the similarity of fuel types, although DOE would also consider transportation distances, available stabilization capabilities, available storage capacities, or a combination of these factors; or (2) Alternative 4b (Regionalization by Geography), where existing and new spent nuclear fuel inventories in the western region of the country will be centralized at a single western site, and existing and new spent nuclear fuel inventories in the eastern region of the country will be centralized at a single eastern site.

Table 5.15-10. Impacts from selected maximum reasonably foreseeable accidents - Alternative 3, Planning Basis (50 and 95 percentile meteorological conditions).

Accident Adjusted Worker Nearest Dose to Offsite Adjusted point

```
estimates of risk of fatal
                       Frequencya  Doseb     Public     MEId       Population     cancers (per
year)
                       (events per (rem)     Accessc    (rem)      Dose (95%)
                       year)                 (rem)                 (person-rem)
                                                                                  MEI
Offsite Population
                                                                                  95%e       50%
95%
1.  Fuel handling
    accident, fuel pin
    breach, venting of 3.1y10-2    (g)       (g)        2.0y10-3   (g)            3.1y10-8   (g)
(g)
    noble gases and    (3.1)
    iodine at HFEFf
2.  Inadvertent critica1.0y10-3    9.7y10-2  1.4y10-3   1.0y10-3   5.9y10-1       5.0y10-10
6.5y10-9               3.0y10-7
    in ICPPh CPP-603   (1.0)j
(6.5y10-6)e            (3.0y10-4)e
    storage facilityi
3.  Fuel melting of small
    number of assemblies
4.5y10-7               7.0y10-5
    at HFEF resulting  1.0y10-5    6.2y10-1  6.5y10-1   5.0y100    1.4y104        2.5y10-8
(4.5y10-2)e            (7.0y100)e
    from seismic event (1.0)
    and cell breach
4.  Material release from
    HFEF resulting from1.0y10-7(k) 4.6y100   3.2y10-1   5.0y100    2.0y103        2.5y10-10
3.6y10-8               1.0y10-7
    aircraft crash and (1.0)
(3.6y10-1)e            (1.0y100)e
    ensuing fire
```

a. Numbers in parentheses indicate multiplication factor used to scale or adjust estimated accident frequencies under Alternative 1, as described in Section 5.15.3.3.

b. A worker is defined as a worker located 100 meters (328 feet) from the point of release.

c. Public individual assumed to be stranded at the nearest point of public access inside the site boundary.

d. MEI = Maximally exposed hypothetical offsite individual located at the nearest site boundary.

e. Maximally exposed individual and offsite population fatal cancer risk = dose y accident frequency y 5.0 y 10-4 fatal cancer per rem (ICRP-60 conversion factor) if dose is less than 20 rem. For doses of 20 rem or more, the ICRP-60 conversion factor is doubled, or 1.0 y 10-3. Numbers in parentheses indicate total number of fatal cancers in the population if the accident occurs.

f. HFEF = Hot Fuel Examination Facility.

g. The safety analysis report utilized for this accident analysis does not provide this information because it was developed prior to DOE Order 5480.23 requiring this information. As demonstrated by the dose to the maximally exposed individual, consequences to the public from this accident could be less than the consequences from Accidents 2 through 4. However, given the high frequency for this accident compared to Accidents 2 through 4, the risk could actually be greater than for Accidents 2 through 4.

h. ICPP = Idaho Chemical Processing Plant.

i. Although three nuclear criticalities associated with spent nuclear fuel reprocessing activities have occurred at the INEL during its 40-year operating history, the estimated frequency for an inadvertent criticality is not based on historic reprocessing data since reprocessing is not considered under this alternative. Nominal frequency estimates vary from 1.0 y 10-4 (CPP-666 underwater storage facility) to 1.0 y 10-3 (CPP-603 underwater storage facility) events per year.

j. Refer to Sections 5.15.3.3 and 5.15.6.2 for details on why this frequency was not adjusted under this alternative.

k. This frequency is a qualitative bounding estimate for a potential aircraft crash, as discussed in Section 5.15.6.4.

5.15.4.4.1 Alternative 4a - Regionalization By Fuel Type - Adjustments in the estimated

accident frequencies and point estimates of risk presented for Alternative 1 would be related to

(1) the receipt, handling, and storage activities associated with the additional spent nuclear fuel inventories; and (2) the increase in overall spent nuclear fuel-related storage, relocation, and handling activities not allowed under Alternative 1.

Because no changes in the accident consequences estimated for Alternative 1 are likely to occur under this alternative from increased fuel inventories (i.e., the same amount of radioactive material would accidentally be released to the environment as discussed in Section 5.15.3.3), no changes are likely in the postulated secondary impacts listed in Table 5.15-8.

Table 5.15-11 summarizes the postulated accidents with the greatest radiological impacts under this alternative.

5.15.4.4.2 Alternative 4b - Regionalization by Geography - Under this alternative, spent

nuclear fuel inventories in the western region of the country would be centralized at either the INEL, Hanford Site, or Nevada Test Site.

Alternative 4b(1) considers regionalization at the INEL.

Alternative 4b(2) considers regionalization at the Hanford Site or Nevada Test Site.

5.15.4.4.2.1 Alternative 4b(1) - Regionalization by Geography (INEL) - Under

this alternative, existing and new spent nuclear fuel inventories in the western region of the country would be centralized at the INEL. Fuel stabilization would be performed in the Fluorinel and Storage (FAST) facility (CPP-666) and a new facility to be constructed, the Fuel Processing Restoration facility (CPP-691), to dissolve spent nuclear fuel and stabilize (i.e., immobilize) radionuclides.

Because the volume of spent nuclear fuel considered under this alternative is only slightly lower than that considered under Alternative 5b, adjustments in the estimated accident frequencies and point estimates of risk for the four accidents presented under Alternative 1 were conservatively considered equivalent to the adjustments required under Alternative 5b (i.e., centralization of all the DOE, Naval Nuclear Propulsion Program, university, and research reactor spent nuclear fuel in the country at the INEL). Adjustments in the estimated accident frequencies and point estimates of risk for the four accidents presented under Alternative 1 would be related to (1) the receipt, handling, and storage activities associated with the additional spent nuclear fuel inventories; and (2) the increase in overall spent nuclear fuel-related storage, relocation, and handling activities not allowed under Alternative 1.

Because no changes in the accident consequences estimated for Alternative 1 are likely to occur under this alternative from increased fuel inventories (i.e., the same amount of radioactive material would accidentally be released to the environment as discussed in Section 5.15.3.3), no changes are likely in the postulated secondary impacts listed in Table 5.15-8.

Table 5.15-11. Impacts from selected maximum reasonably foreseeable accidents - Alternative 4a, Regionalization by Fuel Type (50 and 95 percentile meteorological conditions).

Accident	Adjusted Frequencya (events per year)	Worker Doseb (rem)	Nearest Public Accessc (rem)	Dose to MEId (rem)	Offsite Population Dose (95%) (person-rem)	Adjusted point estimates of risk of fatal cancers (per year) MEI 95%e	Offsite Population 50%	95%
1. Fuel handling accident, fuel pin breach, venting of noble gases and	4.8y10-2 (4.8	(g)	(g)	2.0y10-3	(g)	4.8y10-8	(g)	(g)

```
    iodine at HFEFf
2.  Inadvertent
6.5y10-9             3.0y10-7
    criticality in ICP1.0y10-3    9.7y10-2  1.4y10-3   1.0y10-3   5.9y10-1       5.0y10-10
(6.5y10-6)e          (3.0y10-4)e
    CPP-603 storage   (1.0)j
    facilityi
3.  Fuel melting of
    small number of
4.5y10-7             7.0y10-5
    assemblies at HFEF1.0y10-5    6.2y10-1  6.5y10-1   5.0y100    1.4y104        2.5y10-8
(4.5y10-2)e          (7.0y100)e
    resulting from    (1.0)
    seismic event and
    cell breach
4.  Material release
    from HFEF resultin1.0y10-7(k) 4.6y100   3.2y10-1   5.0y100    2.0y103        2.5y10-10
3.6y10-8             1.0y10-7
    from aircraft cras(1.0)
(3.6y10-1)e          (1.0y100)e
    and ensuing fire
```

a. Numbers in parentheses indicate multiplication factor used to scale or adjust estimated accident frequencies under Alternative 1, as described in Section 5.15.3.3.

b. A worker is defined as a worker located 100 meters (328 feet) from the point of release.

c. Public individual assumed to be stranded at the nearest point of public access inside the site boundary.

d. MEI = Maximally exposed hypothetical offsite individual located at the nearest site boundary.

e. Maximally exposed individual and offsite population fatal cancer risk = dose y accident frequency y 5.0 y 10-4 fatal cancer per rem (ICRP-60 conversion factor) if dose is less than 20 rem. For doses of 20 rem or more, the ICRP-60 conversion factor is doubled, or 1.0 y 10-3. Numbers in parentheses indicate total number of fatal cancers in the population if the accident occurs.

f. HFEF = Hot Fuel Examination Facility.

g. The safety analysis report utilized for this accident analysis does not provide this information because it was developed prior to DOE Order 5480.23 requiring this information. As demonstrated by the dose to the maximally exposed individual, consequences to the public from this accident could be less than the consequences from Accidents 2 through 4. However, given the high frequency for this accident compared to Accidents 2 through 4, the risk could actually be greater than for Accidents 2 through 4.

h. ICPP = Idaho Chemical Processing Plant.

i. Although three nuclear criticalities associated with spent nuclear fuel reprocessing activities have occurred at the INEL during its 40-year operating history, the estimated frequency for an inadvertent criticality is not based on historic reprocessing data since reprocessing is not considered under this alternative. Nominal frequency estimates vary from 1.0 y 10-4 (CPP-666 underwater storage facility) to 1.0 y 10-3 (CPP-603 underwater storage facility) events per year.

j. Refer to Sections 5.15.3.3 and 5.15.6.2 for details on why this frequency was not adjusted under this alternative.

k. This frequency is a qualitative bounding estimate for a potential aircraft crash, as discussed in Section 5.15.6.4.

Because the option exists to restart processing activities, three additional processing-related maximum reasonably foreseeable accidents are considered under this alternative (as discussed in Section 5.15.3.2). Since the amount of radioactive material that would accidentally be released to the environment from these accidents is expected to be lower than in Accidents 3 and 4 (i.e., small fuel melt and aircraft crash at the Hot Fuel Examination Facility, respectively), potential secondary impacts associated with these additional processing-related accidents would be less severe than those presented for the nonprocessing-related accidents in Table 5.15-8.

Table 5.15-12 summarizes the postulated accidents with the greatest radiological impacts under this alternative.

5.15.4.4.2.2 Alternative 4b(2) - Regionalization by Geography (Elsewhere) - Under this

alternative, existing and new spent nuclear fuel inventories in the western region of the country would be centralized at either the Hanford Site or Nevada Test Site. Similar to Alternative 5a, which considers centralization of existing INEL spent nuclear fuel inventories at another DOE site, the inventory of spent nuclear fuel at the INEL would be reduced substantially so that the only spent nuclear fuel at the INEL would consist of fresh fuel generated from operating INEL reactors that had not cooled sufficiently for relocation to the regionalized or centralized site. Therefore, this alternative considers the same amount of material considered under Alternative 1 until the regionalized site could accept existing inventories of INEL spent nuclear fuel and freshly generated spent nuclear fuel that has sufficiently cooled.

Table 5.15-13 summarizes the postulated accidents with the greatest radiological impacts under this alternative.

5.15.4.5 Alternative 5: Centralization. Under this alternative, DOE would collect all current and future spent nuclear fuel inventories from both DOE and the Naval Nuclear Propulsion Program at one site. For the INEL, there are two possibilities: (1) Alternative 5a, in which most spent fuel inventories and activities would take place at the Hanford Site, Savannah River Site, Nevada Test Site, or Oak Ridge Reservation; or (2) Alternative 5b, in which all spent fuel inventories and activities would be centralized at the INEL.

5.15.4.5.1 Alternative 5a: Centralization at Other DOE Sites - This alternative would consider approximately the same amount of material considered under Alternative 1 until the centralized site could accept existing INEL spent nuclear fuel inventories and freshly generated spent

Table 5.**15-12.** Impacts from selected maximum reasonably foreseeable accidents - Alternative 4b(1), Regionalization by Geography (INEL) (50 and 95 percentile meteorological conditions).

Accident	Adjusted Frequency[a] (events per year)	Worker Dose[b] (rem)	Nearest Public Access[c] (rem)	Dose to MEI[d] (rem)	Offsite Population Dose (95%) (person-rem)	Adjusted point estimates of risk of fatal cancers (per year) MEI 95%[e]	MEI 50%	Offsite Population 95%
1. Fuel handling accident, fuel pin breach, venting of noble gases and iodine at HFEF[f]	2.0y10-1 (20.0)	(g)	(g)	2.0y10-3	(g)	2.0y10-7	(g)	(g)
2. Inadvertent criticality in ICPP[h] CPP-603 storage facility[i]	1.0y10-3 (1.0)[j]	9.7y10-2	1.4y10-3	1.0y10-3	5.9y10-1	5.0y10-10	6.5y10-9 (6.5y10-6)[e]	3.0y10-7 (3.0y10-4)[e]
3. Fuel melting of small number of assemblies at HFEF resulting from seismic event and cell breach	1.0y10-5 (1.0)	6.2y10-1	6.5y10-1	5.0y100	1.4y104	2.5y10-8	4.5y10-7 (4.5y10-2)[e]	7.0y10-5 (7.0y100)[e]
4. Material release from HFEF resulting from aircraft crash and ensuing fire	1.0y10-7(k) (1.0)	4.6y100	3.2y10-1	5.0y100	2.0y103	2.5y10-10	3.6y10-8 (3.6y10-1)[e]	1.0y10-7 (1.0y100)[e]
5. Inadvertent nuclear								

criticality ICPPh CPP-666 during processingl	1.0y10-3	9.1y10+0	4.9y10-2	2.8y10-2	5.6y10+0	1.4y10-8	3.1y10-6 (3.1y10-3)	2.8y10-6 (2.8y10-3)
6. Hydrogen in ICPPh CPP-666 dissolver	1.0y10-5	(m)	(m)	6.3y10-4	8.1y10-1	3.2y10-12	(m)	4.1y10-9 (4.1y10-4)
7. Inadvertent dissolution of 30-d cooled fuel at ICPPh CPP-666	1.0y10-6	(m)	(m)	3.0y10-2	2.9y10+1	1.5y10-11	(m)	1.5y10-8 (1.5y10-8)

a. Numbers in parentheses indicate multiplication factor used to scale or adjust estimated accident frequencies under Alternative 1, as described in Section 5.15.3.3.

b. A worker is defined as a worker located 100 meters (328 feet) from the point of release.

c. Public individual assumed to be stranded at the nearest point of public access inside the site boundary.

d. MEI = Maximally exposed hypothetical offsite individual located at the nearest site boundary.

e. Maximally exposed individual and offsite population fatal cancer risk = dose y accident frequency y 5.0 y 10-4 fatal cancer per rem (ICRP-60 conversion factor) if dose is less than 20 rem. For doses of 20 rem or more, the ICRP-60 conversion factor is doubled, or 1.0 y 10-3. Numbers in parentheses indicate total number of fatal cancers in the population if the accident occurs.

f. HFEF = Hot Fuel Examination Facility.

g. The safety analysis report utilized for this accident analysis does not provide this information because it was developed prior to DOE Order 5480.23 requiring this information. As demonstrated by the dose to the maximally exposed individual, consequences to the public from Accident 1 could be less than the consequences from Accidents 2 through 4. However, given the high frequency for Accident 1 compared to Accidents 2 through 4, the risk could actually be greater than for Accidents 2 through 4.

h. ICPP = Idaho Chemical Processing Plant.

i. Although three nuclear criticalities associated with spent nuclear fuel reprocessing activities have occurred during the 40-year operating history of CPP-666, the estimated frequency for an inadvertent criticality in this facility is based on existing spent nuclear conditions and fuel vulnerabilities. Nominal estimates vary from 1.0 y 10-4 (CPP-666 underwater storage facility) to 1.0 y 10-3 (CPP-603 underwater storage facility) events per year.

j. Refer to Sections 5.15.3.3 and 5.15.6.2 for details on why this frequency was not adjusted under this alternative.

k. This frequency is a qualitative bounding estimate for a potential aircraft crash, as discussed in Section 5.15.6.4.

l. The Idaho Chemical Processing Plant has experienced three inadvertent nuclear criticalities during its operating history, the last one 14 years ago. This frequency is based on modern facility conditions and safeguards that exist at CPP-666.

m. The safety analysis report utilized for this accident does not provide this information because it was developed prior to DOE Order 5480.23 requiring this information. However, a comparison of the data presented for this accident to the other accidents provides a relative measure of the impacts to this receptor.

Table 5.15-13. Impacts from selected maximum reasonably foreseeable accidents - Alternative 4b(2), Regionalization by Geography (Elsewhere) (50 and 95 percentile meteorological conditions).

Accident	Adjusted Frequencya (events per year)	Worker Doseb (rem)	Nearest Public Accessc (rem)	Dose to MEId (rem)	Offsite Population Dose (95%) (person-rem)	Adjusted point estimates of risk of fatal cancers (per year)		
						MEI	Offsite Population	
						95%e	50%	95%
1. Fuel handling accident, fuel pin breach, venting of noble gases and iodine at HFEFf	8.6y10-2 (8.6)	(g)	(g)	2.0y10-3	(g)	8.6y10-8	(g)	(g)
2. Inadvertent critica in ICPPh CPP-603	1.0y10-3 (1.0)j	9.7y10-2	1.4y10-3	1.0y10-3	5.9y10-1	5.0y10-10	6.5y10-9	3.0y10-7

```
(6.5y10-6)e          (3.0y10-4)e
    storage facilityi
3.  Fuel melting of small
    number of assemblie1.0y10-5    6.2y10-1  6.5y10-1   5.0y100    1.4y104        2.5y10-8
4.5y10-7             7.0y10-5
    at HFEF resulting  (1.0)
(4.5y10-2)e          (7.0y100)e
    from seismic event
    and cell breach
4.  Material release from
    HFEF resulting from1.0y10-7(k) 4.6y100   3.2y10-1   5.0y100    2.0y103        2.5y10-10
3.6y10-8             1.0y10-7
    aircraft crash and (1.0)
(3.6y10-1)e          (1.0y100)e
    ensuing fire
```

a. Numbers in parentheses indicate multiplication factor used to scale or adjust estimated accident frequencies under Alternative 1, as described in Section 5.15.3.3.

b. A worker is defined as a worker located 100 meters (328 feet) from the point of release.

c. Public individual assumed to be stranded at the nearest point of public access inside the site boundary.

d. MEI = Maximally exposed hypothetical offsite individual located at the nearest site boundary.

e. Maximally exposed individual and offsite population fatal cancer risk = dose y accident frequency y 5.0 y 10-4 fatal cancer per rem (ICRP-60 conversion factor) if dose is less than 20 rem. For doses of 20 rem or more, the ICRP-60 conversion factor is doubled, or 1.0 y 10-3. Numbers in parentheses indicate total number of fatal cancers in the population if the accident occurs.

f. HFEF = Hot Fuel Examination Facility.

g. The safety analysis report utilized for this accident analysis does not provide this information because it was developed prior to DOE Order 5480.23 requiring this information. As demonstrated by the dose to the maximally exposed individual, consequences to the public from this accident could be less than the consequences from Accidents 2 through 4. However, given the high frequency for this accident compared to Accidents 2 through 4, the risk could actually be greater than for Accidents 2 through 4.

h. ICPP = Idaho Chemical Processing Plant.

i. Although three nuclear criticalities associated with spent nuclear fuel reprocessing activities have occurred at the INEL during its 40-year operating history, the estimated frequency for an inadvertent criticality is not based on historic reprocessing data since reprocessing is not considered under this alternative. Nominal frequency estimates vary from 1.0 y 10-4 (CPP-666 underwater storage facility) to 1.0 y 10-3 (CPP-603 underwater storage facility) events per year.

j. Refer to Sections 5.15.3.3 and 5.15.6.2 for details on why this frequency was not adjusted under this alternative.

k. This frequency is a qualitative bounding estimate for a potential aircraft crash, as discussed in Section 5.15.6.4.

fuel that had cooled sufficiently. On demonstration of the centralized site's capability to receive INEL spent nuclear fuel, the inventory of spent fuel at the INEL would be reduced substantially so that the only spent nuclear fuel at the INEL would consist of fresh fuel generated from operating INEL reactors that had not cooled sufficiently for relocation to the centralized site.

Adjustments in estimated accident frequencies and point estimates of risk presented for Alternative 1 would be related to (1) the receipt, handling, and storage activities associated with the additional spent nuclear fuel inventories; and (2) the increase in overall spent fuel-related storage, relocation, and handling activities not allowed under Alternative 1. Because no changes in the accident consequences estimated for Alternative 1 are likely to occur under this alternative from increased fuel inventories (i.e., the same amount of radioactive material would accidentally be released to the environment as discussed in Section 5.15.3.3), no changes are likely in the postulated secondary impacts presented in Table 5.15-8. Table 5.15-14 summarizes the postulated accidents with the greatest radiological impacts under these alternatives.

5.15.4.5.2 Alternative 5b: Centralization at the INEL - Adjustments in estimated

accident frequencies and point estimates of risk presented for Alternative 1 would be related to (1) the receipt, handling, and storage activities associated with the additional spent nuclear fuel inventories; and (2) the increase in overall spent nuclear fuel-related storage, relocation, and handling activities not allowed under Alternative 1.

Because no changes in the accident consequences estimated for Alternative 1 are likely to occur under this alternative from increased fuel inventories (i.e., the same amount of radioactive material would accidentally be released to the environment as discussed in Section 5.15.3.3), no changes are likely in the postulated secondary impacts presented in Table 5.15-8.

Table 5.15-15 summarizes the postulated accidents with the greatest radiological impacts under this alternative.

Because the option exists to restart processing activities, three additional processing-related maximum reasonably foreseeable accidents are considered under this alternative (as discussed in **Section 5.15.3.2).** Since the amount of radioactive material that would accidentally be released to the environment from these accidents is expected to be lower than Accidents 3 and 4 (i.e., small fuel melt and aircraft crash at the Hot Fuel Examination Facility, respectively), potential secondary impacts associated with these additional processing-related accidents would be less severe than those presented for the nonprocessing-related accidents in Table 5.15-8.

Table 5.15-14. Impacts from selected maximum reasonably foreseeable accidents - Alternative 5a, Centralization at Other DOE Sites (50 and 95 percentile meteorological conditions).

Accident	Adjusted Frequency[a] (events per year)	Worker Dose[b] (rem)	Nearest Public Access[c] (rem)	Dose to MEI[d] (rem)	Offsite Population Dose (95%) (person-rem)	Adjusted point estimates of risk of fatal cancers (per year)		
						MEI	Offsite Population	
						95%[e]	50%	95%
1. Fuel handling accident, fuel pin breach, venting of noble gases and iodine at HFEF[f]	8.6y10-2 (8.6)	(g)	(g)	2.0y10-3	(g)	8.6y10-8	(g)	(g)
2. Inadvertent critica in ICPP[h] CPP-603 storage facility[i]	1.0y10-3 (1.0)[j]	9.7y10-2	1.4y10-3	1.0y10-3	5.9y10-1	5.0y10-10	6.5y10-9 (6.5y10-6)[e]	3.0y10-7 (3.0y10-4)[e]
3. Fuel melting of small number of assemblie at HFEF resulting from seismic event and cell breach	1.0y10-5 (1.0)	6.2y10-1	6.5y10-1	5.0y100	1.4y104	2.5y10-8	4.5y10-7 (4.5y10-2)[e]	7.0y10-5 (7.0y100)[e]
4. Material release from HFEF resulting from aircraft crash and ensuing fire	1.0y10-7(k) (1.0)	4.6y100	3.2y10-1	5.0y100	2.0y103	2.5y10-10	3.6y10-8 (3.6y10-1)[e]	1.0y10-7 (1.0y100)[e]

a. Numbers in parentheses indicate multiplication factor used to scale or adjust estimated accident frequencies under Alternative 1, as described in Section 5.15.3.3.

b. A worker is defined as a worker located 100 meters (328 feet) from the point of release.

c. Public individual assumed to be stranded at the nearest point of public access inside the site boundary.

d. MEI = Maximally exposed hypothetical offsite individual located at the nearest site boundary.

e. Maximally exposed individual and offsite population fatal cancer risk = dose y accident frequency y 5.0 y 10-4 fatal cancer per rem (ICRP-60 conversion factor) if dose is less than 20 rem. For doses of 20 rem or more, the ICRP-60 conversion factor is doubled, or 1.0 y 10-3. Numbers in parentheses indicate total number of fatal cancers in the population if the accident occurs.

f. HFEF = Hot Fuel Examination Facility.

g. The safety analysis report utilized for this accident analysis does not provide this information because it was developed prior to DOE Order 5480.23 requiring this information. As demonstrated by the dose to the maximally exposed individual, consequences to the public from this accident could be less than the consequences from Accidents 2 through 4. However, given the high frequency for this accident compared to Accidents 2 through 4, the risk could actually be greater than for Accidents 2 through 4.

h. ICPP = Idaho Chemical Processing Plant.

i. Although three nuclear criticalities associated with spent nuclear fuel reprocessing activities have occurred at the INEL during its 40-year operating history, the estimated frequency for an inadvertent criticality is not based on historic reprocessing data since reprocessing is not considered under this alternative. Nominal frequency estimates vary from 1.0 y 10-4 (CPP-666 underwater storage facility) to 1.0 y 10-3 (CPP-603 underwater storage facility) events per year.

j. Refer to Sections 5.15.3.3 and 5.15.6.2 for details on why this frequency was not adjusted under this alternative.

k. This frequency is a qualitative bounding estimate for a potential aircraft crash, as discussed in Section 5.15.6.4.

Table 5.15-15. Impacts from selected maximum reasonably foreseeable accidents - Alternative 5b, Centralization at the INEL (50 and 95 percentile meteorological conditions).

Accident	Adjusted Frequencya (events per year)	Worker Doseb (rem)	Nearest Public Accessc (rem)	Dose to MEId (rem)	Offsite Population Dose (95%) (person-rem)	Adjusted point estimates of risk of fatal cancers (per year)		
						MEI		Offsite Population
						95%e	50%	95%
1. Fuel handling accident, fuel pin breach, venting of noble gases and iodine at HEFEf	2.0y10-1 (20.0)	(g)	(g)	2.0y10-3	(g)	2.0y10-7	(g)	(g)
2. Inadvertent criticality in ICP storage facilityi	1.0y10-3 (1.0)j	9.7y10-2	1.4y10-3	1.0y10-3	5.9y10-1	5.0y10-10	6.5y10-9 (6.5y10-6)e	3.0y10-7 (3.0y10-4)e
3. Fuel melting of small number of assemblies at HFEF resulting from seismic event and cell breach	1.0y10-5 (1.0)	6.2y10-1	6.5y10-1	5.0y100	1.4y104	2.5y10-8	4.5y10-7 (4.5y10-2)e	7.0y10-5 (7.0y100)e
4. Material release from HFEF resultin from aircraft cras and ensuing fire	1.0y10-7(k) (1.0)	4.6y100	3.2y10-1	5.0y100	2.0y103	2.5y10-10	3.6y10-8 (3.6y10-1)e	1.0y10-7 (1.0y100)e
5. Inadvertent nuclear criticality ICPPh CPP-666 during processingl	1.0y10-3	9.1y10+0	4.9y10-2	2.8y10-2	5.6y10+0	1.4y10-8	3.1y10-6 (3.1y10-3)	2.8y10-6 (2.8y10-3)
6. Hydrogen in ICPPh CPP-666 dissolver	1.0y10-5	(m)	(m)	6.3y10-4	8.1y10-1	3.2y10-12	(m)	4.1y10-9 (4.1y10-4)
7. Inadvertent dissolution of 30-day cooled fuel at ICPPh CPP-666	1.0y10-6	(m)	(m)	3.0y10-2	2.9y10+1	1.5y10-11	(m)	1.5y10-8 (1.5y10-2)

a. Numbers in parentheses indicate multiplication factor used to scale or adjust estimated accident frequencies under Alternative 1, as described in Section 5.15.3.3.

b. A worker is defined as a worker located 100 meters (328 feet) from the point of release.

c. Public individual assumed to be stranded at the nearest point of public access inside the site boundary.

d. MEI = Maximally exposed hypothetical offsite individual located at the nearest site boundary.

e. Maximally exposed individual and offsite population fatal cancer risk = dose y accident frequency y 5.0 y 10-4 fatal cancer per rem (ICRP-60 conversion factor) if dose is less than 20 rem. For doses of 20 rem or more, the ICRP-60 conversion factor is doubled, or 1.0 y 10-3. Numbers in parentheses indicate total number of fatal cancers in the population if the accident occurs.

f. HFEF = Hot Fuel Examination Facility.

g. The safety analysis report utilized for this accident analysis does not provide this information because it was developed prior to DOE Orders requiring this information. As demonstrated by the dose to the maximally exposed individual, consequences to the public from this accident could be less than the consequences from Accidents 2 through 4. However, given the high frequency for this accident compared to Accidents 2 through 4, the risk could actually be greater than for Accidents 2 through 4.

h. ICPP = Idaho Chemical Processing Plant.

i. Although three nuclear criticalities associated with spent nuclear fuel reprocessing activities have occurred during the 40-year operating history of CPP-666, the estimated frequency for an inadvertent criticality in this facility is based on existing spent nuclear conditions and fuel vulnerabilities. Nominal estimates vary from 1.0 y 10-4 (CPP-666 underwater storage facility) to 1.0 y 10-3 (CPP-603 underwater storage facility) events per year.

j. Refer to Sections 5.15.3.3 and 5.15.6.2 for details on why this frequency was not adjusted under this alternative.

k. This frequency is a qualitative bounding estimate for a potential aircraft crash, as discussed in Section 5.15.6.4.

l. The Idaho Chemical Processing Plant has experienced three inadvertent nuclear criticalities during its operating history, the last one 14 years ago. This frequency is based on modern facility conditions and safeguards that exist at CPP-666.

m. The safety analysis report utilized for this accident does not provide this information because it was developed prior to DOE Order 5480.23 requiring this information. However, a comparison of the data presented for this accident to the other accidents provides a relative measure of the impacts to this receptor.

5.15.5 Impacts from Postulated Maximum Reasonably Foreseeable Toxic Material Accidents

Like radioactive materials, toxic materials (e.g., chemicals) are involved in a variety of operations, including spent nuclear fuel-related activities, at the INEL. As a result of these operations and activities, the potential exists for releases of toxic materials to the environment from the same types of initiators considered in determining the radiological accident scenarios discussed in Section 5.15.4. This section summarizes analyses of postulated accident scenarios associated with spent nuclear fuel activities that could result in the release of toxic materials from their confinements.

5.15.5.1 Identification of Toxic Chemicals at the INEL. The facilities at the INEL use

many types and quantities of chemically toxic materials. To determine the spent fuel-related chemicals that exist in sufficient quantities to present health effects to workers or the offsite population, DOE performed an initial screening of the chemical inventories at the INEL. This screening consisted of identifying those hazardous chemicals at the INEL listed in the Superfund Amendments and Reauthorization Act of 1986 (SARA) 312 Report for 1992 (Priestly 1992) that (1) exist in bulk quantities [assumed to be greater than 227 kilograms (500 pounds)]; or (2) exceed reportable quantities [usually 0.45 kilogram (1 pound)] on the EPA Title III List of Lists (EPA 1990), which includes hazardous chemicals defined in the following:

- SARA Section 302, Extremely Hazardous Substances (40 CFR Part 355, Appendixes A and B, List of Extremely Hazardous Substances and Their Threshold Planning Quantities) (CFR 1993)
- Comprehensive Environmental Response, Compensation, and Liability Act Hazardous

Substances (40 CFR Part 302, Table 302.4, Lists of Hazardous Substances and Reportable Quantities) (CFR 1992a)

- SARA Section 313, Toxic Chemicals (CFR 1992b)
- Federal Register list of 100 extremely hazardous chemicals (FR 1994)

5.15.5.2 Selection of Spent Nuclear Fuel-Related Toxic Chemicals Requiring

Accident Analysis. As indicated by the screening methodology discussed above, toxic chemical inventories are located throughout INEL facilities in varying quantities and are involved in nearly all operations and activities performed by INEL facilities, including spent nuclear fuel-related activities. The screening identified no toxic chemicals associated with the dry storage of spent nuclear fuel. Except for processing-related activities that could be performed under the Regionalization and Centralization at INEL alternatives [i.e., Alternatives 4b(1) and 5b, respectively], the screening identified activities associated with the underwater storage of spent nuclear fuel (e.g., maintaining water chemistry) as the only spent nuclear-fuel related activities that might utilize toxic chemicals in sufficient quantities to present a potential for health effects to workers or the offsite population, or potential contamination of the environment. For Alternatives 4b(2) and 5a, in which DOE would relocate INEL spent nuclear fuel inventories and related activities to other DOE sites, the existing toxic chemical inventories at the INEL would be expected to slightly decrease. For Alternatives 4b(1) and 5b, in which the INEL could potentially resume processing activities, a substantial increase in existing chemical inventories, primarily hydrofluoric acid and anhydrous ammonia, would be expected. No substantial changes in existing spent nuclear fuel-related toxic chemical inventories would be expected under Alternatives 1, 2, or 3.

To demonstrate how the consequences of the same accident at an identical hypothetical facility constructed at the Hanford Site or the Savannah River Site under this alternative would compare to the INEL (based on local geological and meteorological conditions), Appendix D summarizes postulated accident scenarios for a new Expended Core Facility that DOE could construct at any of the sites considered in this EIS.

To determine potential accident scenarios associated with handling or storing toxic chemicals at the various spent nuclear fuel-related facilities, DOE performed an extensive review of existing safety analyses and walkdowns of various facilities. This review identified two nonprocessing-related toxic chemicals at the Idaho Chemical Processing Plant - nitric acid and chlorine - as requiring further evaluation to determine potential health effects to workers and the offsite population. Additionally, two toxic chemicals that would be required to support the resumption of processing activities at the Idaho Chemical Processing Plant - hydrofluoric acid and anhydrous ammonia - were identified as requiring further evaluation(6). Although spent fuel-related facilities at the Idaho Chemical Processing Plant use several other toxic chemicals (e.g., oxalic acid), the quantities of these chemicals are not sufficient to present an impact to workers or the environment from accidental releases to the environment. (For postulated accident scenarios involving Naval spent nuclear fuel-related activities at the INEL, refer to Appendix D.)

Because DOE determined that it needed to evaluate postulated toxic chemical accidents at the Idaho Chemical Processing Plant as part of this EIS, it did not consider postulated toxic chemical

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6. Although bulk quantities of nitric acid would be required to perform processing activities that could be resumed Alternatives 4b(1) and 5b, the consequences of processing-related accidents involving nitric acid would be bounded by the hydrofluoric acid and anhydrous accidents analyzed in Sections 5.15.3.3. and 5.15.3.4., respectively. Therefore, this analysis focuses on a potential nitric acid accident resulting from the nonprocessing spent nuclear fuel-related activities considered under the other alternatives.

accidents at the Advanced Test Reactor Storage Canal and the Hot Fuel Examination Facility that could be involved in spent fuel-related activities(7) for further evaluation in this EIS for the following reasons:

- In general, quantities of spent nuclear fuel-related chemicals at the Idaho Chemical Processing Plant are substantially greater than those at the Advanced Test Reactor Storage Canal and Hot Fuel Examination Facility.
- The Idaho Chemical Processing Plant is located approximately 1,000 meters (1,094 yards) closer to the nearest site boundary than the Advanced Test Reactor.

Based on a review of safety documentation for the Test Area North spent nuclear fuel underwater storage facility and discussions with facility personnel, DOE determined that none of the toxic chemicals identified in the screening (Section 5.15.5.1) is related to spent fuel handling or storage activities.

5.15.5.3 Toxic Chemical Accident Analysis. For chemically toxic materials, several government agencies recommend quantifying health effects that cause short-term effects as threshold values of concentrations in air or water. The long-term health consequences of human exposure to toxic materials are not as well understood as the long-term health consequences related to radiation exposure. Thus, the potential health effects for exposures to toxic chemicals are more subjective than those for radioactive materials. Factors such as receptor locations, terrain, meteorological conditions, release conditions, and characteristics of chemical inventories are required parameters for determinations of airborne concentrations of toxic chemicals at various distances from a postulated point of release.

EPICodeTM was used to estimate airborne concentrations resulting from spent nuclear fuel-related toxic chemical releases at the INEL. [For a detailed description of EPICodeTM, refer to Slaughterbeck et al. (1995).]

To determine the potential health effects from accidental releases of toxic chemicals, this analysis compared the concentrations determined by EPICodeTM against Emergency Response Planning Guideline values, where available. These values, which are specific for each substance, are related to three general severity levels:

- Exposure to concentrations greater than Emergency Response Planning Guideline-1 values for a period of time greater than 1 hour results in an unacceptable likelihood that a person would experience mild transient adverse health effects, or perception of a clearly defined objectionable odor.
- Exposure to concentrations greater than Emergency Response Planning Guideline-2 values for a period of time greater than 1 hour results in an unacceptable likelihood that a person would experience or develop irreversible or other serious health effects, or symptoms that could impair one's ability to take protective action.
- Exposure to concentrations greater than Emergency Response Planning Guideline-3 values for a period of time greater than 1 hour results in an unacceptable likelihood that a person would experience or develop life-threatening health effects.

If there were no Emergency Response Planning Guideline values for a toxic substance, the analysis substituted other chemical toxicity values, as follows:

- Threshold limit values/time-weighted average values (ACGIH 1988) substituted for Emergency Response Planning Guideline-1. This is the time-weighted average concentration for a normal 8-hour workday and a 40-hour workweek to which nearly all workers could be repeatedly exposed, day after day, without adverse effect.
- Level of concern values (equal to 0.1 of the immediately dangerous to life or health values - see below) substituted for Emergency Response Planning Guideline-2. The level of concern value is the concentration of a hazardous substance in the air above which there might be

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7. The scope of this analysis has been restricted to the Advanced Test Reactor fuel storage canal. Everything inside the reactor gas-tight boundary and associated with reactor operations has been excluded from consideration because reactor operations are not related to the spent nuclear fual activities considered in this EIS.

serious irreversible health effects or death as a result of a single exposure for a relatively short period of time.

- Immediately dangerous to life or health values are substituted for Emergency Response Planning Guideline-3. The immediately dangerous to life or health value is the maximum concentration from which a person could escape within 30 minutes without a respirator and without experiencing any impairment of escape or irreversible side effects (NIOSH 1990).

As stated in the above section, four toxic chemicals - chlorine, nitric acid, hydrofluoric acid, and anhydrous ammonia - at the Idaho Chemical Processing Plant were identified as requiring further evaluation to estimate potential health effects to workers and the public. The following sections summarize the analyses performed for these chemicals.

5.15.5.3.1 Accidental Chlorine Release - Chlorine, while not directly associated with spent nuclear fuel-related activities at the INEL, is used to treat drinking water supplies at the various spent fuel facilities. Therefore, an analysis of a postulated accidental chlorine release at the Idaho Chemical Processing Plant was performed to determine potential impacts on workers operating the spent fuel-related facilities.

At the Idaho Chemical Processing Plant, chlorine is contained in two pressurized bottles [65 atmospheres at 20yC (68yF)], a 68-kilogram (150-pound) bottle and a 55-kilogram (120-pound) bottle, totaling 123 kilograms (270 pounds). To be conservative, DOE assumed that a breach of the drain line causes an instantaneous release of the total inventory of both tanks. The highest chlorine concentrations at the receptor locations would result from the largest release over the shortest time period. Therefore, the release duration was assumed to be approximately 5 minutes.

An accidental chlorine release from one of the chlorine tanks could be initiated by one of several events, such as a handling event, piping or valve rupture, or human error. Because the two tanks are physically separated, an accidental simultaneous release from both tanks would require a common initiator such as a delivery accident, a common maintenance failure, or a natural phenomena event (e.g., seismic) that damaged or punctured both tanks. The frequency of an accidental release from one pressurized tank is 1.0 y 10-4 event per year (EPA/FEMA/DOT 1987). A common cause failure resulting in the release of chlorine from two separated tanks is assumed to be no greater than 5 percent of the time given for the first tank failure. Therefore, the estimated frequency of an accidental release from both tanks is 5.0 y 10-6 events per year (with no credit taken for pressure vessel management and training).

Table 5.15-16 summarizes the concentrations of the subject chlorine release at the following receptor locations: a facility worker, a member of the public stranded at the nearest point of public access inside the INEL boundary, and a maximally exposed hypothetical member of the public located at the nearest site boundary. As listed in Table 5.15-10, the peak chlorine concentrations for facility workers could result in life-threatening health effects (i.e., Emergency Response Planning Guideline-3 values are exceeded) for both conservative (95 percentile) and average (50 percentile) meteorological conditions.

Table 5.15-16. Summary of chemical concentrations for postulated nonprocessing-related accidental releases at the Idaho Chemical Processing Plant under Alternatives 1 through 5.

Receptor Location	Chemical Concentrations (milligrams per cubic meter)a			
	95% Meteorologyb		50% Meteorologyc	
	Chlorine	Nitric Acide	Chlorine	Nitric Acide
	ERPG-1d = 3 (1)	TWA = 5.2 (2)	ERPG-1 = 3 (1)	TWA = 5.2 (2)
	ERPG-2 = 9 (3)	LOC = 25.5 (10)	ERPG-2 = 9 (3)	LOC = 25.5 (10)
	ERPG-3 = 60 (20)	IDLH = 255 (100)	ERPG-3 = 60 (20)	IDLH = 255 (100)
1. Worker located at 100 meters (325 feet).	84,000 (28,000)	250 (95)	1,620 (540)	33 (13)

2. Nearest point of public access where a member of the public is assumed stranded at the time of the release.f	19.5 (6.5)	0.32 (0.12)	1.89 (0.63)	0.049 (0.019)
3. Maximally exposed hypothetical individual located at the nearest site boundary.g	4.2 (1.4)	0.12 (0.047)	0.42 (0.14)	0.016 (0.006)

a. Numbers in parentheses reflect concentrations in parts per million.
b. The 95 percentile meteorology is based on Class F (unfavorable) meteorological conditions with 0.5 meter per second (1.1 miles per hour) wind speed for receptors located within 2 kilometers (1.2 miles) of the release and 2 meters per second (4.5 miles per hour) for receptors beyond 2 kilometers of the release.
c. The 50 percentile meteorology is based on Class D (typical) meteorological conditions with 4.5 meters per second (10 miles per hour) wind speed for all receptors.
d. ERPG = Emergency Response Planning Guidelines.
e. Because Emergency Response Planning Guideline values are not available for nitric acid, time-weighted average values are substituted for ERPG-1 values, level of concern values are substituted for ERPG-2 values, and immediately dangerous to life or health values are substituted for Emergency Response Planning Guideline-3 values. Refer to Section 5.15.5.3 for further information regarding the use of these values.
f. The nearest point of public access from this postulated release is 5,870 meters (6,419 yards).
g. The nearest site boundary is located at 14,000 meters (15,310 yards).

Peak chlorine concentrations estimated at the nearest point of public access can exceed the Emergency Response Planning Guideline-2 value assuming 95 percentile meteorological conditions, as listed in Table 5.15-10. Symptoms associated with exposure to these concentrations could include burning of the eyes, nose, and throat, coughing, choking, and possibly skin burns.

As listed in Table 5.15-16, the estimated peak averaged chlorine concentration at the nearest site boundary would be above the Emergency Response Planning Guideline-1 value for 95 percentile meteorological conditions. However, due to the nature of the release, this concentration probably would not last for more than a few minutes. Therefore, it would be likely that individuals at this distance would experience no more than mild transient adverse health effects.

This analysis took limited credit for emergency response actions following a chlorine release in calculating the concentrations listed in Table 5.15-16. To mitigate the consequences of a chlorine release to the environment, the same emergency response programs and actions described for radiological accident scenarios (Section 5.15.4.1) would be initiated following the release. Therefore, actual health effects experienced by persons inside the site boundary would realistically be less than the values listed in Table 5.15-16.

Because the estimated airborne concentration of chlorine at 100 meters (328 feet) substantially exceeds the guidelines listed in Table 5.15-16, workers could be fatally injured or could receive long-term or permanent health effects. Potential secondary impacts associated with the chlorine accident scenario would involve economic impacts such as workers' compensation, medical bills, and potential lawsuits. No other secondary impacts, such as impacts on national defense or biotic resources, were identified.

5.15.5.3.2 Accidental Nitric Acid Release - Nitric acid is used at various spent

nuclear fuel-related storage facilities for maintaining the chemistry of the water used in underwater storage facilities(8).
Based on the toxic chemical screening discussed in Section 5.15.5.1, review of existing safety analyses, walkdowns of spent nuclear fuel-related facilities, and interviews with INEL

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8. Although bulk quantities of nitric acid would be required to perform processing activities that

could be resumed under Alternatives 4b(1) and 5b, the consequences of processing-related accidents
involving nitric acid would be bounded by the hydrfluoric acid and anhydrous accidents analyzed in Sections 5.15.5.3.3. and 5.15.5.3.4., respectively. Therefore, this analysis focuses on a potential nitric acid accident resulting from the non-processing spent nuclear fuel-related activities considered under the other alternatives.

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personnel, DOE determined that the potential exists for an accidental release of nitric acid from one of two 1,135 liters (300-gallon) storage tanks used to support spent nuclear fuel-related water treatment activities at the Idaho Chemical Processing Plant. Because one of the tanks is usually empty, the two tanks have separate valves, and they are physically separated, DOE could not identify a reasonably likely initiator that could cause an accidental simultaneous release from both tanks.

The quantity of nitric acid assumed available for release from a single initiator would be (1,135 liters) 300 gallons. The following assumptions were made for this analysis:

- An initiating event causes severe structural damage (e.g., large puncture) to one of the tanks.
- The entire inventory of nitric acid is released into the containment wall surrounding the storage tank.
- The area of the containment wall is approximately 28 square meters (300 square feet).
- The total release of nitric acid [i.e., 1.135 liters (300 gallons)] evaporates into the atmosphere before the implementation of emergency response procedures can recover the nitric acid.

Table 5.15-16 summarizes the concentrations of the nitric acid release at the following receptor locations for both conservative (95 percentile) and average (50 percentile) meteorological conditions:
a facility worker, a member of the public stranded at the nearest point of public access inside the INEL boundary, and a maximally exposed hypothetical member of the public at the nearest site boundary. The estimated frequency for this event is 1 y 10-5 events per year.

This analysis took limited credit for emergency response actions following a nitric acid release in calculating the concentrations listed in Table 5.15-16. To mitigate the consequences of a release to the environment, the same emergency response programs and actions described for radiological accident scenarios (Section 5.15.4.1) would be initiated following a nitric acid release. Therefore, actual health effects experienced by persons inside the site boundary would realistically be less than the values listed in Table 5.15-16.

Other than limited economic secondary impacts, no other secondary impacts would be likely if this accident occurred.

5.15.5.3.3 Accidental Hydrofluoric Acid Release - To resume spent nuclear fuel

processing activities at the Fluorinel and Storage (FAST) facility (CPP-666), which is currently shutdown and being placed in a permanent shutdown mode, bulk quantities of hydrofluoric acid would be required to support the dissolution process.
A hydrofluoric acid storage tank with an operating capacity of approximately 30,283 liters (8,000 gallons) is located in the Idaho Chemical Processing Plant facility area to support processing activities, although only 11,356 liters (3,000 gallons) of hydrofluoric acid remain in the tank, and efforts are currently underway to remove the remaining hydrofluoric acid in the tank from the INEL site.

Table 5.15-17 summarizes the potential impacts upon a maximally exposed hypothetically offsite individual located at the nearest site boundary [14,000 meters (15,310 yards)] resulting from a potential hydrofluoric acid release at the Idaho Chemical Processing Plant assuming 95 percentile meteorological conditions. Slaughterbeck et al. (1995) provides further details and discussion regarding this postulated accident scenario. Although Slaughterbeck et al. (1995) presents impacts to only the maximally exposed offsite hypothetical individual resulting from this postulated accident for 95 percentile meteorological conditions, a comparison of the airborne concentration of hydrofluoric acid at 14,000 meters (15,310 yards) to the airborne concentrations from other postulated chemical accident scenarios (as presented in Table 5.15-16) at the same receptor distance provides meaningful perspective on the significance of this accident.

Table 5.15-17. Summary of chemical concentrations for postulated processing-related accidental releases at the Idaho Chemical Processing Plant under Alternatives 4b(1) and 5b.

	Chemical Concentrations (milligrams per cubic meter)a	
	95% Meteorologyb	
	Hydrofluoric Acid	Anhydrous Ammonia
Receptor Location	ERPG-1c = 4 (5) ERPG-2 = 17 (20) ERPG-3 = 43 (50)	ERPG-1 = 17 (25) ERPG-2 = 136 (200) ERPG-3 = 680 (1000)
Maximally exposed hypothetical individual located at the nearest boundaryd	0.078 (0.09)	82 (120.6)

a. Numbers in parentheses reflect concentrations in parts per million.
b. The 95 percentile meteorology is based on Class F (unfavorable) meteorological conditions with 0.5 meter per second (1.1 miles per hour) wind speed for receptors located within 2 kilometers (1.2 miles) of the release and 2 meters per second (4.5 miles per hour) for receptors beyond 2 kilometers of the release.
c. ERPG = Emergency Response Planning Guidelines.
d. The nearest site boundary is located at 14,000 meters (15,310 yards).

The estimated frequency for this event is 1 y 10-5 events per year. It should be noted that this potential accident applies only to Alternatives 4b(1) and 5b, and is in addition to the potential chlorine and nitric acid release accidents described in Sections 5.15.5.3.1 and 5.15.5.3.2, respectively.

This analysis took limited credit for emergency response actions following a hydrofluoric acid release in calculating the concentrations listed in Table 5.15-17. To mitigate the consequences of a release to the environment, the same emergency response programs and actions described for radiological accident scenarios (Section 5.15.4.1) would be initiated following a hydrofluoric acid release. Therefore, actual health effects experienced by persons inside the site boundary would realistically be less than the values listed in Table 5.15-17.

Other than limited economic secondary impacts, no other secondary impacts would be likely if this accident occurred.

5.15.5.3.4 Accidental Anhydrous Ammonia Release - To resume spent nuclear

fuel processing activities at the Fluorinel and Storage (FAST) facility (CPP-666), bulk quantities of anhydrous ammonia would be required to support operation of the NOx-Abatement Facility (CPP-1670), a facility that would be constructed to treat airborne effluents from the INEL processing facilities before being released to the environment.

The NOx-Abatement Facility would be expected to utilize two anhydrous ammonia tanks, each with a storage capacity of 68,000 liters (18,000 gallons). Table 5.15-17 summarizes the potential impacts upon the maximally exposed hypothetical offsite individual located at the nearest site boundary [14,000 meters (15,310 yards)] resulting from a short-term release of the contents of both storage tanks [i.e., 136,000 liters (36,000 gallons)] at the Idaho Chemical Processing Plant assuming 95 percentile meteorological conditions. Slaughterbeck et al. (1995) provides further details and discussion regarding this postulated accident scenario. Although Slaughterbeck et al. (1995) presents only impacts to the maximally exposed offsite hypothetical individual resulting from this postulated accident for 95 percentile meteorological conditions, a comparison of the airborne concentration of anhydrous ammonia at 14,000 meters (15,310 yards) to the airborne concentrations from other postulated chemical accident scenarios (as presented in Table 5.15-16) at the same distance provides meaningful perspective on the significance of this accident.

The estimated frequency for this event is 5 y 10-6 events per year. The basis for this estimated frequency is identical to that described for an accidental chlorine release from two separate tanks, as described in Section 5.15.5.3.1. It should be noted that this potential accident applies only to Alternatives 4b(1) and 5b, and is in addition to the potential chlorine and nitric acid release accidents described in Sections 5.15.5.3.1 and 5.15.5.3.2, respectively.

This analysis took limited credit for emergency response actions following an anhydrous ammonia release in calculating the concentrations listed in Table 5.15-17. To mitigate the consequences of a release to the environment, the same emergency response programs and actions described for radiological accident scenarios (Section 5.15.4.1) would be initiated following a hydrofluoric acid release. Therefore, actual health effects experienced by persons inside the site boundary would realistically be less than the values listed in Table 5.15-17.

Other than limited economic secondary impacts, no other secondary impacts would be likely if this accident occurred.

5.15.6 Maximum Reasonably Foreseeable Radiological Accident Scenario Descriptions

The purpose of this section is to summarize the different accident scenarios identified in Section 5.15.4. The Facility Safety Report for the Argonne National Laboratory-West Hot Fuel Examination Facility (ANL 1975) contains further details and discussions for Accident 1, discussed below. Slaughterbeck et al. (1995) provides further details, discussions, and references for Accidents 2 through 7, discussed below. Additional discussions and references regarding the processing-related accidents summarized in this section are also provided in a study performed to determine the potential impacts spent nuclear fuel processing-related accidents could have on the siting of a new production reactor at the INEL (EG&G 1993b). These documents contain additional information, such as release fractions, source terms, and other assumptions used in the accident analyses. Appendix D describes postulated accident scenarios associated with Naval spent nuclear fuel-related facilities and activities at the INEL.

5.15.6.1 Accident 1: Fuel Pin Breach and Venting of Noble Gases and Iodine to

the Environment from a Mechanical Handling Accident at the Argonne National Laboratory-West Hot Fuel Examination Facility. The accident screening methodology discussed in Section 5.15.3 identified a mechanical handling event at the Argonne National Laboratory-West Hot Fuel Examination Facility as an initiator to the maximum reasonably foreseeable accident within the abnormal event frequency range. This event would result in a fuel pin breach and venting of noble gases and iodine to the environment. The identification of this accident as a maximum reasonably foreseeable accident is based on the estimated radiological consequences to the maximally exposed hypothetical offsite individual at the nearest site boundary presented in the Hot Fuel Examination Facility Safety Report (ANL 1975). Other postulated accidents associated with handling spent nuclear fuel in the Hot Fuel Examination Facility before the identification of the fuel pin breach accident as the maximum reasonably foreseeable accident included an inadvertent criticality and a sodium fire. A fuel pin breach accident was chosen as the maximum reasonably foreseeable accident because the estimated frequencies for an inadvertent criticality and a sodium fire in the facility are extremely low (ANL 1975).

The analyses defined in the Facility Safety Report (ANL 1975) made the following assumptions:

- The fuel subassemblies and experimental capsules being examined in the facility were cooled for at least 15 days to ensure that the short-lived fission products had decayed.
- The noble gases and iodines that could be released from this accident scenario were immediately released.
- One hundred percent of the noble gases, 25 percent of the iodines, and 1 percent of particulates were available for escape to the atmosphere.
- The building containment structure, including the building ventilation system, and the Main Cell, including the argon ventilation system, remained operational following the handling accident. This assumption is considered appropriate because the mechanical handling accident scenario under consideration would not initiate a failure in these systems. (Accident 3 considers the simultaneous failure of all these systems in conjunction with the melting of fuel assemblies stored in the facility).

The Facility Safety Report (ANL 1975) contains specific information on the source terms associated with breaching the fuel section of a pin. Because that report does not provide an estimated frequency of occurrence for the subject mechanical handling accident scenario, the analysis used historic information and engineering judgment to determine the conservatively estimated frequency for this accident of 1.0 y 10-2 event per year.

For determining the impacts from this postulated accident scenario, the nearest point of public access is equivalent to the nearest site boundary, which is 5,240 meters (5,730 yards) from the point of the release. Although the Facility Safety Report (ANL 1975) does not estimate consequences to the offsite population resulting from this accident scenario, this analysis reasonably estimated that the exposures (i.e., dose) to the offsite population would be less than the offsite population dose calculated for Accidents 2 through 4 because the dose to the maximally exposed hypothetical individual at the nearest site boundary from this accident would be less than that estimated for Accidents 2 through 4.

5.15.6.2 Accident 2: Inadvertent Nuclear Chain Reaction in Wet Spent Nuclear

Fuel Storage (1 y 1019 fissions, 8-hour release) at the Idaho Chemical Processing Plant CPP-603 Underwater Fuel Storage Facility. The accident screening methodology discussed in Section 5.15.3 identified an inadvertent nuclear criticality associated with underwater spent nuclear fuel storage at the CPP-603 Underwater Fuel Storage Facility as an accident requiring further evaluation.

Other postulated accidents that were considered before the identification of an inadvertent criticality accident as a maximum reasonably foreseeable accident included pool leaks, fuel damage events, and loss of cooling events. This analysis selected an inadvertent nuclear criticality for evaluation in this EIS over the other accidents for the following reasons:

- Postulated inadvertent nuclear criticality accidents have been addressed in virtually all DOE nonreactor EISs and safety analysis reports in which such accidents were reasonably foreseeable because of public concerns regarding the potential for these accidents.
- The Idaho Chemical Processing Plant has experienced three inadvertent nuclear criticality accidents. Although none of these accidents involved a fuel storage facility, they demonstrate the potential and concern for such events.
- The consequences of water leakage from a pool-draining event would present lower prompt consequences to workers than a criticality because the INEL could implement emergency response plans to evacuate workers before the risk to these workers could substantially increase. In addition, a pool drain was considered to be an initiator to a criticality accident.
- Mechanical fuel damage events are less impacting than a nuclear chain reaction scenario because some degree of fuel damage is part of the criticality accident scenario and analysis.

Of the different Idaho Chemical Processing Plant facility areas that store spent nuclear fuel, the CPP-603 Underwater Fuel Storage Facility was selected for analysis of a criticality accident for the following reasons:

- CPP-603 facility storage includes most types of spent nuclear fuel stored elsewhere on the site. Fuel stored at reactor basins is an exception (but was considered in the determination of other reasonably foreseeable accident scenarios) because of its much shorter cooling times after removal from a reactor.
- CPP-603 facility spent nuclear fuel storage quantities are comparable to or exceed the spent nuclear fuel inventories stored elsewhere on the site.
- The CPP-603 facility is an older facility that does not contain all the preventive or mitigative design features found in more modern facilities, such as the CPP-666 Fuel Storage Area.

The analysis selected the underwater fuel storage portion of the CPP-603 facility rather than the Irradiated Fuels Storage Facility portion of the CPP-603 facility because accidents involving graphite fuels in dry storage probably would have less severe potential consequences because they had been removed from reactors for a much longer period of time and, because of their design, would prevent most of the remaining fission products from being released if a criticality accident occurred.

Initiating events that the analysis considered possible to lead to an inadvertent nuclear criticality included operator error, hanger corrosion, equipment failure, an earthquake, pool drain, and an aircraft crash. The scenario discussed in this EIS assumes a postulated criticality scenario that could be initiated by human error, equipment failure, or earthquake. Heat generated from the chain reaction would easily dissipate and thereby avoid fuel melting but would still cause the release of fission products associated with 1 y 1019 fissions over an 8-hour period.

Between 1945 and 1980, 40 known inadvertent criticalities occurred worldwide, none of which involved the handling or storage of spent nuclear fuel in an underwater fuel storage facilities. In addition, between 1975 and 1980, there were 160 nuclear power reactor facilities with underwater fuel storage facilities worldwide. None of these facilities ever had a nuclear criticality associated with its underwater storage facilities. Therefore, it is generally assumed that the likelihood for such an event in a modern underwater storage facility is unlikely, with a frequency estimated at 1 y 10-4 event per year. This estimated frequency is supported by information in the safety analysis report for the CPP-666 underwater storage facility, which is a modern facility (e.g., 1980s vintage) at the INEL used to store various types of spent nuclear fuel. In the CPP-603 Underwater Fuel Storage Facility, however, where spent nuclear fuel inventories have substantially corroded or degraded (DOE 1993c), and where the design of the facility and its supporting equipment do not meet current design specifications, activities associated with handling and storing spent nuclear fuel present an increase in the likelihood for an inadvertent nuclear criticality accident by as much as an order of magnitude. Therefore, this analysis conservatively assumes the estimated frequency for an inadvertent nuclear criticality associated with handling spent nuclear fuel in the CPP-603 Underwater Fuel Storage Facility to be 1 y 10-3 event per year for this analysis.

The handling activities associated with stabilizing CPP-603 facility spent nuclear fuel inventories would occur under each of the five alternatives considered in this EIS. The estimated frequency for an inadvertent criticality at the CPP-603 facility is an order of magnitude larger than that of any other INEL facility (e.g., 1 y 10-3 event per year), and is considered a "worst-case" frequency that bounds changes in estimated criticality frequencies at other INEL facilities resulting from increased handling activities associated with changes in spent nuclear fuel inventories. Therefore, using the estimated criticality frequency related to the CPP-603 as the estimated frequency under each alternative provides a conservative bound on the estimated criticality frequencies for other spent nuclear fuel-related handling and storage facilities.

To determine the accident impacts from this postulated accident scenario, the analysis assumed the worker to be located 100 meters (328 feet) from the event, the nearest point of public access (U.S. Route 20/26) is 5,870 meters (6,420 yards), and the nearest site boundary is located at 14,000 meters (15,310 yards).

5.15.6.3 Accident 3: Earthquake-Induced Breach and Fuel Melt at the Argonne

National Laboratory-West Hot Fuel Examination Facility. The accident screening methodology discussed in Section 5.15.3 identified an earthquake-induced breach and fuel melt at the Argonne National Laboratory-West Hot Fuel Examination Facility as a maximum reasonably foreseeable accident that would present higher radiological consequences to facility workers or the offsite population than other postulated accidents analyzed in the same accident frequency range. The postulated events leading to atmospheric release of radionuclides are as follows:

- The earthquake results in a peak horizontal ground acceleration of sufficient magnitude to cause structural damage to the building structure and a large breach in the main cell.9
- Coincident with the breach, a failure of the fuel subassembly cooling system occurs, resulting in the melting of fresh assemblies.
- Radionuclides from the melting fuel subassemblies are released to the atmosphere.

The estimated probability of an earthquake in the Argonne National Laboratory-West facility area resulting in a peak horizontal acceleration of sufficient magnitude to damage the facility structure and breach the cell is 1 y 10-5 event per year. This analysis conservatively assumes the probability of failure of the building structure, Main Cell, and subassembly cooling to be 1.0, given that the earthquake has occurred. A preliminary assessment of the seismic integrity of the Hot Fuel Examination Facility, as discussed in Slaughterbeck et al. (1995), indicates that, given the current state of analysis, significant failures could result at the Hot Fuel Examination Facility from this earthquake.

In determining the number of fuel assemblies that would be affected during this scenario, the analysis assumed that 20 fuel subassemblies would melt due to failure of the forced cooling in this accident. Although 40 storage positions are available for fuel that would require forced cooling, current plans do not estimate the need to use more than 20 of these positions. The release duration for this scenario is 30 days. To prevent doses greater than 5 rem to the public from this scenario, the analysis assumed intervention by evacuation or prevention of contaminated food consumption, with the calculated doses reflecting this assumption.

To determine the impacts from this postulated accident scenario, the analysis assumed the worker to be located 100 meters (328 feet) from the event, and the nearest point of public access (U.S. Route 20) and the nearest site boundary at 5,240 meters (5,730 yards).

5.15.6.4 Accident 4: Radiological Material Release from the Argonne National

Laboratory-West Hot Fuel Examination Facility Resulting from an Aircraft Crash and Ensuing Fire. The accident screening methodology discussed in Section 5.15.3 identified a radioactive material release from the Argonne National Laboratory-West Hot Fuel Examination Facility resulting from an aircraft crash as the maximum reasonably foreseeable accident in the beyond-design-basis accident frequency range. Of externally initiated events, an aircraft crash into the Hot Fuel Examination Facility is a maximum reasonably foreseeable accident because it could (1) cause a major breach of confinement barriers, (2) involve a large portion of the material at risk, and (3) have a high-energy release mechanism (physical impact followed by a sustained fire). The analysis eliminated other accident scenarios considered in this frequency range because they would not have sufficient energy sources to cause a large breach of confinement and release to the atmosphere. Although the facility contains little combustible material to sustain a fire, a fire caused by aircraft fuel involved in the crash could increase potential consequences over other beyond-design-basis accidents. The major events of an aircraft crash scenario are as follows:

- A large or high-velocity aircraft (e.g., commercial or military) crashes directly into the Hot Fuel Examination Facility.
- The impact has sufficient force to cause catastrophic failure of the building structure, breach of the Main Cell, and loss of forced cooling to subassemblies in the cell.
- The fuel in the aircraft is released to the facility and is ignited.
- The ensuing fire involves the contents of the Main Cell, Decontamination Cell, High Bay Area, and Hot Repair Area, resulting in atmospheric release of radionuclides.

To determine aircraft crash probability, the analysis limited this scenario to large or high-velocity jet airplanes. High-velocity military jets from the U.S. Air Force Base at Mountain Home in southwestern Idaho could enter the airspace of the INEL. In addition, large jet aircraft have been flown at low altitudes in landing configurations over portions of the INEL for vortex tests. The likelihood of a large aircraft crash directly in the Hot Fuel Examination Facility is remote, but possible. Analyses of jet aircraft crashes at specific facilities, such as the Idaho Chemical Processing Plant, have resulted in predicted frequencies on the order of 1.0 y 10-7 event per year. Because specific analyses have not determined the likelihood of an aircraft crash into the Hot Fuel

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9. As discussed in Slaughterbeck et al. (1995), accelerations with any of several potential seismic events with a combined estimated frequency of 1 * 10(-5) per year are beyond the design of the Hot Fuel Examination Facility and were determined to compromise the ability of the structure to maintain confinement. Events this rare are beyond the requirements of DOE Order 5480.28 and DOE-ID Architechtural Engineering Standards for Category 1 (high hazard) facilities.

Examination Facility (although it is expected that fewer flights occur over the Argonne National Laboratory-West facility area than the Idaho Chemical Processing Plant), the analysis conservatively assumed that the frequency for an aircraft crashing into the Hot Fuel Examination Facility is 1.0 y 10-7 per year.

For determining impacts from this postulated accident scenario, the analysis assumed the worker was located 100 meters from the event; and the nearest point of public access (U.S. Route 20) and the nearest site boundary were both at 5,240 meters (5,730 yards).

5.15.6.5 Accident 5: Inadvertent Nuclear Chain Reaction During Spent Nuclear

Fuel Processing (1 x 1019 fissions) at the Idaho Chemical Processing Plant CPP-666 Fluorinel and Storage (FAST) Facility. The accident screening methodology discussed in Section 5.15.3 identified an inadvertent nuclear criticality resulting from spent nuclear fuel reprocessing in the CPP-666 Fluorinel and Storage Facility as a maximum reasonably foreseeable processing accident. Although the CPP-666 Fluorinel and Storage Facility, which historically reprocessed spent nuclear fuel to recover fissionable radionuclides (e.g., uranium-235), is currently shutdown, there may be a need to resume processing operations to dissolve spent nuclear fuel and to stabilize the radionuclides in a waste form. Therefore, while the potential for this accident does not currently exist, the potential would exist if processing-related activities are resumed under Alternatives 4b(1) and 5b (Regionalization and Centralization at the INEL, respectively).

Initiating events that the analysis considered possible to lead to an inadvertent nuclear criticality during processing included human error, equipment failure, an earthquake, an aircraft crash, excessive fissionable radionuclides in the spent nuclear fuel being processed, and reduced neutron poison concentrations. Consistent with the inadvertent criticality scenario associated with underwater storage of spent nuclear fuel described in Section 5.15.6.2, the fission yield associated with this criticality was assumed to be 1 y 1019 fissions. Further information and references regarding this postulated accident scenario are provided in Slaughterbeck et al. (1995) and EG&G (1993b).

As discussed in Section 5.15.2, three inadvertent nuclear criticalities have occurred in INEL processing facilities during the 40-year history of the INEL. The last of these criticalities occurred 14 years ago. As a result of these accidents, administrative controls and facility modifications were implemented to reduce the potential for inadvertent nuclear criticality accidents resulting from processing-related activities. If the decision is made to resume processing operations, these same controls would be utilized. Therefore, the estimated frequency for a potential inadvertent nuclear criticality is assumed to be 1 y 10-3 events per year, which is consistent with assumptions made regarding the potential for an inadvertent criticality resulting from underwater storage and handling of severely degraded spent nuclear fuel (as discussed in Section 5.15.6.2).

Limited credit was taken for mitigative features, such as emergency response programs, in determining worker and public exposures resulting from this postulated accident scenario. However, credit was taken for shielding walls placed in the facility to reduce potential personnel exposures resulting from an inadvertent nuclear criticality.

To determine the accident impacts from this postulated accident scenario, the analysis assumed the worker to be located 100 meters (328 feet) from the event, the nearest point of public access (U.S., Route 20/26) is 5,870 meters (6,420 yards), and the nearest site boundary is located at 14,000 meters (15,310 yards).

5.15.6.6 Accident 6: Radionuclide Release During Spent Nuclear Fuel Processing

at the Idaho Chemical Processing Plant CPP-666 Fluorinel and Storage (FAST) Facility Resulting from a Hydrogen Explosion in the Dissolver Off-Gas System. The accident screening methodology discussed in Section 5.15.3 identified a hydrogen explosion in the CPP-666 Fluorinel and Storage Facility dissolver off-gas system as a maximum reasonably foreseeable processing accident. Despite CPP-666's current shutdown status, there may be a need to resume processing operation to dissolve spent nuclear fuel and stabilize the radionuclides in a waste form.

Therefore, while the potential for this accident does not currently exist, the potential would exist if processing-related activities are resumed under Alternatives 4b(1) and 5b (Regionalization and Centralization at the INEL, respectively).

Initiating events that the analysis considered possible to lead to a hydrogen explosion in the dissolver off-gas system included human error, equipment failure, and an earthquake. Further information and references regarding this postulated accident scenario are provided in Slaughterbeck et al. (1995) and EG&G (1993b).

Limited credit was taken for mitigative features, such as emergency response programs, in determining worker and public exposures resulting from this postulated accident scenario. To determine the accident impacts from this postulated accident scenario, the analysis assumed the worker to be located 100 meters (328 feet) from the event, the nearest point of public access (U.S., Route 20/26) is 5,870 meters (6,420 yards), and the nearest site boundary is located at 14,000 meters (15,310 yards).

5.15.6.7 Accident 7: Radionuclide Release During Spent Nuclear Fuel Processing

at the Idaho Chemical Processing Plant CPP-666 Fluorinel and Storage (FAST) Facility Resulting from the Inadvertent Dissolution of 30-Day Cooled Spent Nuclear Fuel. The accident screening methodology discussed in Section 5.15.3 identified a radionuclide release resulting from the inadvertent dissolution of 30-day cooled spent nuclear fuel in the CPP-666 Fluorinel and Storage Facility as a maximum reasonably foreseeable accident. There may be a need to resume processing operation at CPP-666 to dissolve spent nuclear fuel and stabilize the radionuclides in a waste form. Therefore, while the potential for this accident does not currently exist, the potential would exist if processing-related activities are resumed under Alternatives 4b(1) and 5b (Regionalization and Centralization at the INEL, respectively).

Upon removal from a nuclear reactor, spent nuclear fuel is placed in an underwater storage canal (e.g., Advanced Test Reactor Storage Canal in the Test Reactor Area) to allow the fuel temperature to cool and short-lived radionuclides to decay. Inadvertent processing of spent nuclear fuel that has not had the opportunity to sufficiently cool presents the potential for accidents during dissolution of the fuel. Examples of accidents that could potentially occur are explosions in the dissolver tank and an inadvertent criticality. An explosion resulting from inadvertent dissolving spent nuclear fuel that has not sufficiently cooled (i.e., 30-day cooled fuel) is considered for this analysis since an inadvertent criticality is already considered (as discussed in Section 5.15.6.6).

The potential initiating event considered for this accident involves several operator errors that result in the wrong spent nuclear fuel assemblies being dissolved. First, fuel cooled 30 or fewer days would have to be shipped to and received by the Fluorinel and Storage Facility. Second, operators at the CPP-666 Fluorinel and Storage Facility would have to inadvertently dissolve the 30-day (or fewer) cooled fuel. Based on the individual probability of these events, and the probability that the dissolved fuel would accidentally release radionuclides to the environment, the estimated frequency for this event is 1 y 10-6 events per year. Further information and references regarding this postulated accident scenario are provided in Slaughterbeck et al. (1995) and EG&G (1993b).

Limited credit was taken for mitigative features, such as emergency response programs, in determining worker and public exposures resulting from this postulated accident scenario. To determine the accident impacts from this postulated accident scenario, the analysis assumed the worker to be located 100 meters (328 feet) from the event, the nearest point of public access (U.S., Route 20/26) is 5,870 meters (6,420 yards), and the nearest site boundary is located at 14,000 meters (15,310 yards).

5.16 Cumulative Impacts and Impacts from

Connected or Similar Actions

The INEL already contains major DOE facilities unrelated to spent nuclear fuel that would continue to operate throughout the life of the spent nuclear fuel management program. The activities associated with these existing facilities produce environmental consequences that this EIS has included in the baseline environmental conditions (Chapter 4) against which it has assessed the consequences of the spent nuclear fuel alternatives. In addition, the cumulative impacts assessed in this section include other past, present, and reasonably foreseeable future actions that DOE expects to occur at the INEL, such as spent nuclear fuel management, Naval Nuclear Propulsion Program activities, environmental restoration and waste management activities, as well as any known offsite projects conducted by government agencies, businesses, or individuals. Onsite projects include decontamination and decommissioning, repair, and upgrades of existing facilities. Offsite projects include residential and commercial development, and changes in manufacturing plants.

Consistent with the DOE sliding scale approach and the programmatic aspects of this EIS, cumulative impacts are discussed commensurate with the degree of impact. Therefore, not every area of analysis from Chapter 5 is represented in this section. DOE used information and analyses from Volume 2 of this EIS as input for this section. Section 5.15 of Volume 2 provides a more detailed discussion of cumulative impacts.

Tables 5.16-1 and 5.16-2 list the cumulative impacts identified for each alternative. DOE made necessary adjustments to accommodate the differences between Volume 1 and Volume 2 alternatives. Cumulative impacts from Alternatives 3 and 4a are nominally the same, as are cumulative impacts from Alternatives 1 and 2, 5a and 4b(2), and 5b and 4b(1).

5.16.1 Land Use

Implementation of any of the alternatives would contribute to the cumulative loss of land with open-space land use. However, the cumulative amount of land that would no longer be open space or available for other land uses would be small compared to the size of INEL or regional land uses. As discussed in Section 5.2, Land Use, the maximum land disturbance, 31 acres (0.12 square kilometer) would occur under Alternative 4b(l) [Regionalization by Geography (INEL)] and 5b (Centralization at INEL). While exact maximum figures are not available, over 200 acres (0.81 square kilometer) of vacant land in nearby communities are scheduled for development. Projects that would potentially

Table 5.16-1. Nonhealth-related cumulative impacts.

Discipline/Unit of measure	1 (No Action) and 2 (Decentralization)	3 (1992/1993 Planning Basis) and 4a (Regionalization by Fuel Type)	5a (Centralization at Other Sites) and 4b(2) [Regionalization by Geography (Elsewhere)]	5b (Centralization at INEL) and 4b(1) [Regionalization by Geography (INEL)]	Comments
Land use/amount of land not available for other use	Small compared to regional land uses	Small compared to regional land uses	Small compared to regional land uses	Small compared to regional land uses	
Socioeconomics/change in number of total jobs	Overall decrease of 4,800	Overall decrease of 2,300	Overall decrease of 4,400	Overall decrease of 1,400	Under all alternatives, additional jobs created would be more than offset by decrease from other actions
Cultural resources/minimum number of potentially historic	6 structures and 0 sites	70 structures and 22 sites	11 structures and 0 sites	70 structures and 22 sites	Under all alternatives, the potential for reduction of the number of cultural resources

exists structures/archaeological sites disturbeda						
Air resourcesb		Below applicable standards	Below applicable standards	Below applicable standards	Below applicable standards	
Waste management/waste volume total pending disposition	High-leveld	12,100 m3	12,500 m3	17,000 m3	12,100 m3	These volumes reflect existing and newly generated wastes pending disposition under each alternative
	Transuranice	67,000 m3	73,000 m3	67,000 m3	87,000m3	
	Mixed low-level	17,000 m3	17,000 m3	17,000 m3	167,000 m3	
	Low-levele	46,000 m3	72,000 m3	47,000 m3	840,000 m3	
	Hazardousf	12,000 m3	12,000 m3	12,000 m3	12,000 m3	
	Commercial and industriale	540,000 m3	590,000 m3	550,000 m3	590,000 m3	

a. Numbers for archaeological sites potentially impacted would be expected to increase as cultural resource surveys are conducted for projects on acreage previously unsurveyed.
b. See Table 5.16-2 for cumulative health risks related to air emissions.
c. Derived in Freund (1994), Morton and Hendrickson (1995).
d. High-level waste includes both liquid and calcine forms. Liquid high-level waste totals do not include processing, which would increase these reported totals by some degree. Numbers represent total volume of all high-level waste stored onsite.
e. Numbers do not include existing dispositioned waste stored or buried onsite.
f. Numbers represent total volume stored onsite.

Table 5.16-2. Health-related cumulative impacts.

Radiologicala	Pathway	Type of impact	1 (No Action) and 2 (Decentralization)	3 (1992/1993 Planning Basis) and 4a (Regionalization by Fuel Type)	5a (Centralization at Other Sites) and 4b(2) [Regionalization by Geography (Elsewhere)]	5b (Centralization at INEL) and 4b(1) [Regionalization by Geography (INEL)]	Comments
Public	Atmoshperic	Estimated excess fatal cancers	<1	<1	<1	<1	
	Groundwater	Estimated excess fatal cancers	<1	<1	<1	<1	
	Biotic	Estimated excess fatal cancers	<1	<1	<1	<1	This pathway would involve harvesting game animals and vegetation that can assimilate radioactivity onsite.
Workersb	Atmospheric	Estimated excess fatal cancers	Negligible	Negligible	Negligible	Negligible	Overall cancers expected to be less than baseline because fewer employees under all alternatives.
	Occupational exposures	Estimated excess fatal cancers	1	1	1	1	
Public	Atmospheric	Estimated	<1	<1	<1	<1	

	(Carcinogens)	lifetime cancers					
	Atmospheric (Noncarcinogens)[c]	Estimated adverse health effects	0	0	0	0	

Table 5.16-2. (continued).

Radiological[a]	Pathway	Type of impact	1 (No Action) and 2 (Decentralization)	3 (1992/1993 Planning Basis) and 4a (Regionalization by Fuel Type)	5a (Centralization at Other Sites) and 4b(2) [Regionalization by Geography (Elsewhere)]	5b (Centralization at INEL) and 4b(1) [Regionalization by Geography (INEL)]	Comments
Workers[b]	Atmospheric (Carcinogens)	Estimated lifetime cancers	<1	<1	<1	<1	
	Atmospheric (Noncarcinogens)[c]	Estimated adverse health effects	0	0	0	0	
	Routine workplace safety hazards	Estimated fatalities	3	3	3	3	Estimates differ only slightly between alternatives due to changes in number of workers. Total workplace safety hazards are fewer than those encountered by the average worker in private industry.

a. Approximate numbers. See Volume 2, Section 5.12 and Volume 2, Appendix F for detailed discussion and analyses.
b. Estimated excess fatal cancers calculated from dosimeter measurements.

disturb previously disturbed land are scheduled to take place on about 270 acres (1.0 square kilometer) at the INEL. An additional 1,060 acres (4.3 square kilometers) of open space INEL land may also be disturbed by potential projects.

5.16.2 Socioeconomics

Any of the spent fuel management alternatives would cause minimal cumulative impacts on socioeconomic resources of the INEL region when combined with known onsite or offsite projects. The implementation of any of the alternatives would create temporary additional employment during construction; the upper bound of potential impact would occur under Alternatives 3, 4a, 4b(1), and 5b. In the long term, the expected future decrease in employment at the INEL would more than offset this increase, as well as any increases from known offsite projects. Therefore, the cumulative effect on employment would be an overall decrease. Potential population declines associated with the cumulative effect on regional employment are estimated to represent less than 2 percent of the total regional population. It is unlikely that a change in population of this size would generate any notable long-term adverse impacts to housing, community services, or public finance in the region.

5.16.3 Cultural Resources

The types of cumulative impacts on cultural resources are the same for all alternatives. Each of the alternatives, when combined with associated onsite and offsite activities, could potentially impact cultural resources. However, surveying, recording, and stabilizing archeological and historic sites and structures at the INEL would increase scientific knowledge of the region's cultural resources, although stabilizing resources may adversely affect their significance to Native American groups. The unchecked deterioration of both structures and historic documents on nuclear facilities at the INEL could have a long-term adverse impact on these resources. Long-term effects may also occur to traditional resources that may not be mitigated through scientific studies. Cumulative impacts associated with Alternatives 3 and 4a (see 1992/1993 Planning Basis and Regionalization by Fuel Type) and Alternatives 5b and 4b(1) [Centralization at INEL and Regionalization by Geography (INEL)] have the greatest potential for impacts. Alternatives 1 and 2 (No Action and Decentralization) would have the least potential for impacts.

5.16.4 Air Quality

For radiological emissions, all cumulative impacts at onsite and offsite locations are well below applicable standards and are a small fraction of the dose received from natural background sources. The highest dose to a maximally exposed member of the public would be caused by Alternatives 4b(l) and 5b and would be about 0.05 millirem per year. When added to the projected dose from other INEL proposed projects of approximately 0.7 millirem per year and the maximum baseline dose of 0.05 millirem per year, this dose would be well below the National Emissions Standards for Hazardous Air Pollutants limit of 10 millirem per year (CFR 1992c). The National Council on Radiation Protection and Measurements has identified a dose rate below 1 millirem per year as negligible (NCRP 1987).

Cumulative nonradiological impacts were analyzed in terms of concentrations of criteria and toxic air pollutants in ambient air. At site boundary locations, the highest potential concentrations of criteria pollutants remain well below applicable National Ambient Air Quality Standards (CFR 1991). Concentrations at public road locations within the INEL boundary could increase significantly from current levels, but would remain well below applicable standards.

5.16.5 Occupational and Public Health and Safety

Work activities and the exposure to radiological and chemical hazards under each of the alternatives would be similar to those at present. Therefore, average radiation dose, exposure to toxic chemicals, and associated health effects would be related to the number of site workers under each alternative. Because the cumulative impacts of any alternative would be a decrease in the number of workers, the cumulative impact of any alternative on occupational health would be a decrease in health effects to the levels listed in Table 5.16-2. The incidence of expected health effects would be similar for all alternatives because the relative difference in employment effects (and therefore the effects on the health of those employed) is very small. While air emissions present the only calculable pathway for public radiation exposure due to spent nuclear fuel management, groundwater and biotic pathways are included in Table 5.16-2 due to Volume 2 analyses of environmental restoration and waste management activities.

Occupational health data concerning historic accidents are incomplete and not readily available. Though historical records of accidents at the INEL are available, occupational doses were not always known and reported. Worker dose data are currently being collected and analyzed under a National Institute of Occupational Safety and Health program. Historical offsite doses associated with the INEL are summarized in the Idaho National Engineering Laboratory Historical Dose Evaluation (DOE 1991). The Centers for Disease Control and Prevention is conducting a more comprehensive reconstruction of doses from INEL operations. An assessment of the cumulative impacts of accidents at the Site to the health of INEL workers is not available at this time.

Cumulative transportation impacts are addressed in Volume 1, Appendix I.

5.16.6 Materials and Waste Management

The total volumes of waste existing and projected to be generated or shipped to the INEL from spent nuclear fuel management, as well as known onsite and offsite projects over a 10-year period, are presented by waste stream for each alternative in Table 5.16-1. The storage of low-level waste for incineration is not considered to be restrictive between 1995 and 2005; however, beyond 2005 additional capacity may be required. Although spent nuclear fuel management would not cause permitted storage capacity to exceed its limits without available treatment or disposal under the No Action and Decentralization Alternatives, it is anticipated that the permitted storage capacity for mixed low-level waste will be exceeded during the first year of a 10-year timeframe. All other alternatives include facility construction for storage of, or shipping of, mixed low-level waste; therefore, storage capacity is accounted for.

5.17 Adverse Environmental Effects That Cannot Be Avoided

The construction and operation of any of the alternatives at the INEL could result in adverse impacts to the environment. Changes in project design and other measures would avoid or otherwise mitigate most of these impacts to minimal levels. This section identifies only adverse impacts that mitigation could not reduce to minimal levels or avoid altogether.

Under each alternative, the continued deterioration of structures with historic preservation potential and historic documents on nuclear facilities could have a long-term adverse impact on these resources at the INEL. However, DOE would avoid potentially adverse impacts by preserving the historic value of the property through appropriate research, or by conducting limited rehabilitation on these structures. This impact is discussed in Section 5.4.

As discussed in Section 5.2, the maximum loss of habitat would involve the conversion to industrial use of about 31 acres (0.12 square kilometers) of previously disturbed habitat that is of low quality and limited use to wildlife; conversion would occur under Alternatives 4b(1) and 5b.

The amount of radiation exposure from normal operation of the spent nuclear fuel facilities would be a small fraction of the existing natural background at the INEL and would be well below applicable regulatory standards. In all cases, the number of estimated additional cancers is a small fraction of 1 per year of site operation through 2035. This effect is discussed in Section 5.12.

With the exception of the unavoidable temporary increase in noise due to construction activities, any impact of noise from activities under any of the alternatives would be minor and highly unlikely.

An unavoidable adverse impact of the proposed activities with any of the alternatives would be an accident either at the involved facilities or during the transportation of construction materials or dismantled components. Accidents are discussed in Section 5.15; transportation is discussed in Section 5.11.

Spent nuclear fuel management supports the continuation of beneficial activities such as radiopharmaceutical and other research. An unavoidable adverse impact of the No-Action Alternative would be a reduction in the support of such activities.

As discussed in Section 5.14, the increased generation of industrial solid waste that would occur under all alternatives is an unavoidable adverse impact. However, the amount generated under each alternative would be a very small percentage increase from the projected 1995 baseline levels.

5.18 Relationship Between

Short-Term Use of the Environment and the Maintenance and Enhancement of Long-Term Productivity

Under all alternatives, short-term use of the environment is generally associated with resource demands for spent nuclear fuel management activities. Resources demands also include those required for upgrade, construction, and operation of facilities. These short-term demands and uses provide a foundation and direction for the long-term productivity of INEL; they also have an effect on the success of future INEL missions. A brief discussion of the influence proposed actions would have on the long-term productivity of the INEL follows. The INEL missions, including spent nuclear fuel, are discussed in Section 2.1.

The No-Action Alternative would provide few long-term benefits and would not allow DOE-Idaho Operations Office to fulfill its missions regarding the disposition and management of spent nuclear fuel. The activities proposed in this alternative would not support future proposals for disposal technology development. Further, the No-Action Alternative could bring enforcement actions because it would not meet all the requirements of existing DOE regulatory commitments such as those outlined in the Federal Facility Agreement and Consent Order.

To a varying degree, Alternatives 2, 3, and 4(a) would provide more flexibility than other alternatives for fulfilling existing or future missions and actions at INEL. Near- and long-term actions under these alternatives ensure compliance with regulatory requirements and protection of the environment. Furthermore, these alternatives would provide a diverse decisionmaking platform for future actions concerning disposition of DOE spent nuclear fuel. Facilities constructed and technologies developed under these alternatives could be used for a wide range of activities such as interim treatment and storage or preparation and packaging for transportation offsite.

The approach that would be taken for spent nuclear fuel under Alternatives 4b(2) and 5a could confine and hinder long-term productivity at INEL. Efforts would focus on shipment of spent nuclear fuel to other locations. No emphasis would be placed on solving particular spent nuclear fuel disposal problems or increasing the understanding of how certain spent nuclear fuels react over time.

Alternatives 4b(1) and 5b would direct INEL's future mission and development primarily toward large-scale canning and characterization, storage, and disposal of all INEL and DOE regional or complex-wide spent nuclear fuel. These alternatives could limit INEL's flexibility in redirecting or enhancing future INEL-specific missions.

5.19 Irreversible and Irretrievable Commitment of Resources

The irreversible and irretrievable commitment of natural and manmade resources resulting from the construction and operation of facilities related to the spent nuclear fuel alternatives would involve materials and resources that could not be recovered or recycled or that would be consumed or reduced to unrecoverable forms. Some of these commitments would be irretrievable because of the nature of the commitment or the cost of reclamation. For example, the construction and operation of spent nuclear fuel facilities at the INEL would consume irretrievable amounts of electrical energy, fuel, concrete, steel, aluminum, copper, plastics, lumber, sand, gravel, groundwater, and miscellaneous chemicals.

Alternatives 4b(1) and 5b are each estimated to require approximately 11,000 megawatt-hours per year of electricity, 1,100,000 liters (290,000 gallons) per year of fuel oil, and 48 million liters (13 million gallons) per year of water above the projected baseline (1995) usage of these resources (see Section 5.13). These changes would represent a modest increase of 5.3 percent, 9.9 percent, and 0.7 percent respectively, and are well within current system capabilities and usage limits. All other alternatives would place smaller demands on these resources, commensurate with the level of construction and operation activities proposed.

Alternatives 4b(1) and 5b would also commit 31 acres (0.12 square kilometer) of previously disturbed land to industrial use; the conversion of this acreage would result in the commitment of poor quality wildlife habitat and natural resource services. Alternatives 4b(1) and 5b would involve the greatest irretrievable consumption of other resources, such as construction materials and operating supplies. However, this demand would not constitute a permanent drain on local resources or involve any material that is in short supply in the region.

Other commitments would be irreversible because the construction or operation of facilities related to the spent nuclear fuel alternatives would consume the resource. Proposed activities would also require an expenditure of labor that would be irretrievable.

5.20 Potential Mitigation Measures

This section summarizes measures that DOE would use to avoid or reduce impacts to the environment caused by spent nuclear fuel management activities at the INEL. The potential mitigation measures for each aspect of the affected environment described below are the same under each alternative. Section 5.7 of Volume 1 discusses other generalized measures DOE could use.

5.20.1 Pollution Prevention

DOE is committed to comply with Executive Order 12856, Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements; Executive Order 12873. Federal Acquisition, Recycling and Waste Prevention; and applicable DOE Orders and guidance documents in planning and implementing pollution prevention at the INEL. The DOE views source reduction as the first priority in its pollution prevention program, followed by an increased emphasis on recycling. Waste treatment and disposal are considered only when prevention or recycling is not possible or practical.

5.20.2 Cultural Resources

The lack of detailed specifications associated with the proposed construction at the INEL under various alternatives precludes identifying specific project impacts and potential mitigation measures for particular structures and facilities. Basic compliance under cultural resource law involves five steps that would be essentially the same under all alternatives. These steps are (a) identification and evaluation of resources in danger of impact, (b) assessment of effects to these resources in consultation with the State Historic Preservation Office and representatives of the Shoshone-Bannock Tribes, (c) development of plans and documents to minimize any adverse effects. (d) consultation with the Advisory Council on Historic Preservation and tribal representatives as to the appropriateness of mitigation measures, and (e) implementation of potential mitigation measures. Therefore, if a cultural resource survey has not been performed in an area planned for ground disturbance under one of the proposed alternatives, consultation would be initiated with the Idaho State Historic Preservation Office and the survey would be conducted prior to any disturbance. If cultural resources were discovered, they would be evaluated according to National Register criteria. Wherever possible. important resources would be left undisturbed. If the impacts are determined to be adverse and it is not feasible to leave the resource undisturbed, then measures would be initiated to reduce impacts. All mitigation plans would be developed in consultation with the State Historic Preservation Office and the Advisory Council on Historic Preservation and would conform to appropriate standards and guidelines established for historic preservation activities by the Secretary of the Interior.

Some actions may affect areas of religious, cultural, or historic value to Native Americans. DOE has implemented a Working Agreement (DOE 1992d) to ensure communication with the Shoshone-Bannock Tribe, especially relating to the treatment of archeological sites during excavation, as mandated by the Archeological Resources Protection Act (ARPA 1979); the protection of human remains, as required under the Native American Graves Protection and Repatriation Act (NAGPRA 1990); and the free exercise of religion as protected by the American Indian Religious Freedom Act (AIRFA 1978). In keeping with DOE Native American policy (DOE 1990), DOE Order 1230.2 (DOE 1992c), and procedures to be defined in the final Cultural Resources Management Plan for the INEL, DOE would conduct Native American consultation during the planning and implementation of all proposed alternatives. Procedures for dealing with the inadvertent discovery of human remains would be consistent with the Native American Graves Protection and Repatriation Act (NAGPRA 1990). If human remains are discovered, DOE will notify all tribes that have expressed an interest in the repatriation of graves as required under NAGPRA, including the Shoshone-Bannock, Shoshone, Painte, and the Northwestern band of the Shoshone Nation. These tribes will then have an opportunity to claim the remains and associated artifacts in accordance with the requirements of NAGPRA. Procedures for the repatriation of "cultural items" in accordance with NAGPRA will be described in a curation agreement that will be finalized by June 1996.

In addition to consultation, other measures would mitigate potential adverse effects to Native American Resources, in particular effects to air, water, plants, animals, and visual setting. These measures include avoidance of sensitive areas, placement of facilities within existing areas of construction, revegetation with native plants of areas with ground disturbance, monitoring of plants and animals within hunting and gathering areas for radiological contamination, reducing noise and night lights outside of existing facilities, monitoring tanks, ponds and runoff for contaminants, minimizing ground disturbance, use of dust suppressers during construction, and use of filters and other air pollutant control equipment to reduce air contaminants.

5.20.3 Traffic and Transportation

All onsite shipments of spent nuclear fuel would be in compliance with ID Directive 5480.3, "Hazardous Materials Packaging and Transportation Safety Requirements." These requirements provide assurance that, under normal conditions, the INEL would meet as-low-as-reasonably-achievable conditions, reasonably foreseeable accident situations (those with probability of occurrence greater than 1x10^-7 per year) would not result in a loss of shielding or containment or a criticality, and an unintentional release of radioactive material would result in a timely response.

DOE would approve the type packages used for onsite shipments or would obtain a Nuclear Regulatory Commission or DOE certificate of compliance. If the onsite package did not have Nuclear Regulatory Commission or DOE certification, the user of the package would have to establish how administrative controls or other potential mitigating measures would ensure that the package would maintain containment and shielding integrity. The administrative and emergency response considerations would provide sufficient control so that accidents would not result in loss of containment or shielding, in criticality, or in an uncontrolled release of radioactive material that would create a hazard to the health and safety of the public or workers. Accident mitigation is described below.

5.20.4 Accidents

The DOE would initiate INEL emergency response programs, as appropriate, following the occurrence of an accident to prevent or mitigate consequences. These emergency response programs, implemented in accordance with 5300-DOE series Orders, typically involve emergency planning, emergency preparedness, and emergency response actions. Participating government agencies with plans that are interrelated with the INEL Emergency Plan for Action include the State of Idaho, Bingham County, Bonneville County, Butte County, Clark County, Jefferson County, the Bureau of Indian Affairs, and Fort Hall Indian Reservation. When an emergency condition exists at a facility, the Emergency Action Director is responsible for recognition, classification, notification, and protective action recommendations. Each emergency response plan utilizes resources specifically dedicated to assist a facility in emergency management. These resources include but are not limited to the following:

- INEL Warning Communications Center
- INEL Fire Department
- Facility Emergency Command Centers
- DOE Emergency Operations Centers
- County and State Emergency Command Centers
- Medical, health physics, and industrial hygiene specialists
- Protective clothing and equipment (respirators, breathing air supplies, etc.)
- Periodic training exercises and drills within and between the organizations involved in implementing the response plans

6. REFERENCES

6. REFERENCES

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APPENDIX C Savannah River Site Spent Nuclear Fuel Management Program

Department of Energy Programmatic
Spent Nuclear Fuel Management
and
Idaho National Engineering Laboratory
Environmental Restoration and
Waste Management Programs
Final Environmental Impact Statement
Volume 1
Appendix C
Savannah River Site
Spent Nuclear Fuel Management Program
April 1995
U.S. Department of Energy
Office of Environmental Management
Idaho Operations Office

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FIGURES

1. INTRODUCTION

The U.S. Department of Energy (DOE) is engaged in two related decisionmaking processes concerning: (1) the transportation, receipt, processing, and storage of spent nuclear fuel (SNF) at the DOE Idaho National Engineering Laboratory (INEL) which will focus on the next 10 years; and (2) programmatic decisions on future spent nuclear fuel management which will emphasize the next 40 years.

DOE is analyzing the environmental consequences of these spent nuclear fuel management actions in this two-volume Environmental Impact Statement (EIS). Volume 1 supports broad programmatic decisions that will have applicability across the DOE complex and describes in detail the purpose and need for this DOE action. Volume 2 is specific to actions at the INEL. This document, which limits its discussion to the Savannah River Site (SRS) spent nuclear fuel management program, supports Volume 1 of the EIS. Other documents supporting Volume 1 focus on spent nuclear fuel management programs for the Hanford Site, INEL, Naval Nuclear Propulsion Program, and other sites.

As part of its planning process for this two-volume EIS, DOE issued an Implementation Plan on October 29, 1993. The organization of this document is consistent with the provisions established in the Implementation Plan and are outlined below:

- Chapter 2 contains background information related to the SRS and the framework of environmental regulations pertinent to spent nuclear fuel management.
- Chapter 3 identifies spent nuclear fuel management alternatives that DOE could implement at the SRS, and summarizes their potential environmental consequences.
- Chapter 4 describes the existing environmental resources of the SRS that spent nuclear fuel activities could affect.
- Chapter 5 analyzes in detail the environmental consequences of each spent nuclear fuel management alternative and describes cumulative impacts. The chapter also contains information on unavoidable adverse impacts, commitment of resources, short-term use of the environment and mitigation measures.

2. BACKGROUND

The chapter contains an overview of the Savannah River Site (SRS) and a description of the regulatory framework related to the actions that this document evaluates. In addition, it discusses the U.S. Department of Energy (DOE) Spent Nuclear Fuel (SNF) Management Program as it relates to the SRS. Finally, it describes the representative sites located on the SRS that could serve as locations for spent nuclear fuel facilities.

2.1 SRS Overview

The SRS is a key DOE facility for research on and processing of special nuclear materials. The U.S. Government built the Site in the early 1950s to produce the basic materials - primarily plutonium-239 and tritium - used in the fabrication of nuclear weapons. The DOE Savannah River Operations Office manages the SRS, and Westinghouse Savannah River Company (WSRC) operates the Site under contract to DOE.

2.1.1 Site Description

The SRS occupies an area of approximately 310 square miles (800 square kilometers) in western South Carolina, in a generally rural area about 25 miles (40 kilometers) southeast of Augusta, Georgia, and 12 miles (19 kilometers) south of Aiken, South Carolina (Figure 2-1). The Savannah River forms the southwestern border of the SRS, which includes portions of Aiken, Barnwell, and Allendale Counties. The average population density (1990 census data) in the six-county region of influence around the Site is 140 people per square mile (54 per square kilometer); the largest concentration is 2,595 people per square mile (1,002 per square kilometer) in the City of Augusta (HNUS 1992). Four other population centers - Aiken, Allendale, Barnwell, and North Augusta, South Carolina - are within 22 miles (40 kilometers) of the Site. Three small towns - Jackson, New Ellenton, and Snelling, South Carolina - are adjacent to the SRS boundary to the northwest, north, and east, respectively. Based on 1990 U.S. Census Bureau data, the population within a 50-mile (80-kilometer) radius of the SRS is approximately 620,100 (Arnett et al. 1993).

The Site consists primarily of managed upland forest with some wetland areas. Facilities and roadways occupy approximately 5 percent of the SRS land area. Access to the Site is controlled, with public transportation limited to through traffic on South Carolina Highway 125 (SRS Road A), U.S. Highway 278, SRS Road 1, and the CSX Railroad corridor.

Figure 2-1. National location of SRS.

The SRS contains 15 major production, service, and research and development (R&D) areas that previously supported nuclear materials production and can support processing operations and waste management activities. Major SRS facilities include five nuclear reactors, two chemical separations plants, a fuel and target fabrication facility, the Defense Waste Processing Facility (DWPF), the Replacement Tritium Facility, a heavy-water rework plant, and the Savannah River Technology Center (SRTC), formerly called the Savannah River Laboratory. In addition, the University of Georgia Research Foundation operates the Savannah River Ecology Laboratory (SREL) on the Site under contract to DOE. Under an interagency agreement, the U.S. Forest Service operates the Savannah River Forest Station, which manages the natural resources and secondary roads on the Site. These facilities are in defined areas scattered across the Site. Each area is identified by a letter designation, as summarized in Table 2-1. Figure 2-2 shows the locations of the principal SRS facilities. The reactor, waste storage, and separations areas are at least 4 miles (6 kilometers) inside the nearest SRS boundary.

The primary SRS facilities were related to the production of nuclear materials. M-Area manufactured fuel and target components for shipment to the SRS reactors. Originally, the Site operated five reactors; at present, all are in shutdown status. Shielded railroad cars transported irradiated fuel to the F- or H-Area Canyon for the recovery of nuclear materials. The F- and H-Area separations processes dissolve irradiated components in acid, and extract and separate the desired nuclear materials. In H-Area, additional processes extract other products from irradiated components.

DOE neutralizes and stores the high-level liquid radioactive waste generated by the separations facilities in underground tanks. DOE plans to process this waste into a borosilicate glass waste form in the Defense Waste Processing Facility when that facility becomes operational, and to store this glass waste form at the SRS until an offsite geological repository is available. [DOE has prepared a Supplemental EIS related to Defense Waste Processing Facility operations (DOE 1994a).] In addition to the underground waste storage tanks, DOE has established a centrally located 196-acre (0.8-square-kilometer) site between F- and H-Areas, called E-Area, for the disposal of solid low-level radioactive waste and the storage of transuranic (TRU) radioactive waste and mixed (hazardous and radioactive) waste. The Site also has a central sanitary landfill and buildings in the Central Shops (N-Area) for the storage of nonradioactive hazardous wastes and mixed waste. DOE is preparing an EIS on waste management activities at the SRS (DOE 1995a).

Table 2-1. Description of functions and principal facilities at SRS areas.

Area	Function	Principal facilities
A	Main DOE administration area, research laboratories	Main administration building, Savannah River Technology Center, Savannah River Ecology Laboratory, powerhouse
B	Wackenhut Services, Inc., administration area (security)	Administration building, WSRC Engineering building, WSRC training buildings
C	One of five SRS reactors	C-Reactor, training facilities, cooling basin
D	Central powerhouse and heavy-water rework	Powerhouse, heavy-water rework facility
E	Waste disposal and storage	Solid Waste Disposal Facility
F	Process plutonium	F-Area Canyon, FB-Line, tank farm
G	Various support functions	Spread throughout the Site: railroad yard, U.S. Forest Service installations
H	Process uranium and tritium	H-Area Canyon, HB-Line, Effluent Treatment Facility, tank farm, Receiving Basin for Offsite Fuels, Consolidated Incineration Facility
K	One of five SRS reactors	K-Reactor, cooling basins, cooling tower
L	One of five SRS reactors	L-Reactor, cooling basins
M	Production of fuel and target assemblies	Slug and target production facilities, effluent treatment facility
N	Receiving	Central Shops
P	One of five SRS reactors	P-Reactor, cooling basins
R	One of five SRS reactors	R-Reactor, cooling basins
S	Process high-level radioactive waste	Defense Waste Processing Facility
TNX	Applied research and development	Analytical laboratory, Defense Waste Processing Technology facilities, various mockups, effluent treatment facilities
Z	Waste treatment and handling	Saltstone facility

The Site contains facilities for processing support and for research and development. These include operational coal-fired powerhouses in A-, D-, and H-Areas that generate electricity and steam. The largest powerhouse, which is in D-Area, produces electricity and sends process steam to C-, F-, H-, and S-Areas through a 7-mile (11-kilometer) steam line. D-Area also contains the heavy-water rework facility at which DOE purified the deuterium oxide (heavy water) used as the moderator and coolant in SRS reactors. TNX-Area facilities study chemical and waste processing problems and test production-scale equipment. Finally, A-Area facilities include the Savannah River Technology Center, the Savannah River Ecology Laboratory, and the DOE and Westinghouse Savannah River Company administrative offices.

Figure 2-2. Location of principal SRS facilities (see Table 2-1).

The SRS employs approximately 20,000 people. Most of these employees work for Westinghouse Savannah River Company and its subcontractors. The remainder work for DOE, the Savannah River Ecology Laboratory, Wackenhut Services, Inc., the U.S. Forest Service, and other contractors.

2.1.2 Site History

The U.S. Atomic Energy Commission (AEC), a DOE predecessor agency, selected the location for the SRS in November 1950 after a study of more than 100 prospective sites. The government selected E. I. du Pont de Nemours and Company, Inc., to build and operate the facility. Construction began in February 1951; the basic plant was completed in 1956 at a cost of $1.1 billion, including the land. On October 3, 1952, operations began with the startup of a unit of the heavy-water extraction plant. Criticality occurred in the first production reactor on December 28, 1953.

In 1972, the AEC designated the SRS as the nation's first National Environmental Research Park. Through the years, scientists have performed a wide range of investigations on the diverse habitats, flora, and fauna of the Site.

2.1.3 Mission

The historic mission of the SRS was to serve the national security interests of the United States by safely processing nuclear materials while protecting the health and safety of employees and the public and protecting the environment. The SRS was responsible for producing tritium and special nuclear materials for national defense. At present, it supports the viability of the weapons stockpile by recycling limited-life components. The SRS also produces isotopes for nonweapons applications in the nation's space program and for medical applications.

The SRS spent nuclear fuel mission is to manage DOE-owned spent fuel in a cost-effective way that protects the safety of SRS workers, the public, and the environment. The goals of near-term activities are the accurate quantification and characterization of DOE-owned spent nuclear fuel, assessment of spent nuclear fuel storage facilities, elimination of current spent nuclear fuel storage vulnerabilities, and identification of technologies and requirements for interim management and ultimate disposition of spent nuclear fuel.

2.1.4 Management

The DOE Savannah River Operations Office manages the SRS; the Westinghouse Savannah River Company operates the Site under contract to DOE. Westinghouse assumed operational responsibility in April 1989 from E. I. du Pont de Nemours and Company, Inc., which had operated the Site since 1951.

2.2 Regulatory Framework

This section summarizes the framework of environmental protection regulations applicable to spent nuclear fuel management at the SRS. The framework is based on Federal and South Carolina laws and one local ordinance, as discussed below. Volume 1 (Section 7.0) of this Environmental Impact Statement (EIS) provides additional information on the major Federal environmental laws and regulations, Executive Orders, and DOE Orders that apply to spent nuclear fuel management alternatives.

2.2.1 Federal

The U.S. Environmental Protection Agency (EPA) has authorized South Carolina to implement most provisions of the Clean Air Act, Resource Conservation and Recovery Act, and Clean Water Act that apply to SRS spent nuclear fuel management. EPA Region IV has the lead responsibility for Clean Air Act standards for radionuclide emissions from DOE facilities, imposing monitoring and approval requirements on SRS spent nuclear fuel management activities that could result in radionuclide emissions.

In addition, EPA Region IV has Resource Conservation and Recovery Act authority over radioactive hazardous (mixed) waste management, affecting wastes from spent nuclear fuel processing.
EPA Region IV and the DOE Savannah River Operations Office have entered into a Federal Facility Compliance Agreement on SRS mixed waste management.

The U.S. Army Corps of Engineers District Engineer for the Charleston District implements the Clean Water Act Section 404 and the Rivers and Harbors Act permitting program for SRS spent nuclear fuel construction activities that would affect U.S. waters.

In accordance with the Endangered Species Act, the SRS would consult with the U.S. Fish and Wildlife Service, Charleston Field Office on impacts that spent nuclear fuel construction activities could have on threatened and endangered species.

2.2.2 State

The South Carolina Department of Health and Environmental Control implements the following State laws that would affect SRS spent nuclear fuel management activities:

- Pollution Control Act (nonradioactive emissions and discharges, and nonhazardous waste management)
- Hazardous Waste Management Act (nonradioactive hazardous waste management)
- Safe Drinking Water Act
- Groundwater Use Act
- Stormwater Management and Sediment Reduction Act

The U.S. Army Corps of Engineers District Engineer for the Charleston District has an agreement with the South Carolina Department of Health and Environmental Control whereby that department issues Clean Water Act Section 401 water quality certifications. The South Carolina Department of Health and Environmental Control also receives SRS reports in accordance with the Emergency Planning and Community Right-To-Know Act.

The South Carolina State Department of Archives and History includes the State Historic Preservation Office. In accordance with the National Historic Preservation Act, the SRS would consult with the State Historic Preservation Officer on impacts that construction activities could have on cultural resources.

2.2.3 Local

The only local requirement applicable to SRS spent nuclear fuel management is the Aiken County Sediment Control Ordinance, which would affect construction activities.

2.3 Spent Nuclear Fuel Management Program at the Savannah River Site

This EIS addresses the management of approximately 2,742 metric tons of heavy metal (MTHM; 3,023 tons) of spent nuclear fuel that would be stored at various locations within the DOE Complex over the next 40 years (1995-2035). At present, DOE has stored approximately 206.3 MTHM (227.4 tons), or about 8 percent of this material, at the SRS. The spent nuclear fuel currently stored at the SRS that DOE has included in the analyses in this document includes:

- 184.4 MTHM (203.3 tons) of Savannah River Defense Production [highly enriched uranium (HEU) aluminum-clad fuels], including plutonium target material, and other aluminum-clad fuels
- 4.6 MTHM (5.1 tons) of commercial spent fuel (primarily zirconium-clad)
- 11.9 MTHM (13.1 tons) of test and experimental reactor Zircaloy-clad fuel
- 5.4 MTHM (6.0 tons) of test and experimental reactor stainless steel-clad fuel

Spent nuclear fuel is currently stored in the Receiving Basin for Offsite Fuels (RBOF), in three reactor disassembly basins, and in basins in F- and H-Canyons. Table 2-2 shows the quantity of spent fuel stored at these facilities.

Table 2-2. SRS Fuel Inventory by Facility.

Facility	Quantity (MTHM)
Receiving Basin for Offsite Fuel	60.73
L-Reactor Disassembly Basin	118.11
K-Reactor Disassembly Basin	3.32
P-Reactor Disassembly Basin	1.41
F-Canyon	22.63
H-Canyon	0.07
Total	206.27

Source: Wichmann (1995).

The F- and H-Area Canyons at the SRS are among the only remaining operable chemical separations facilities of their kind in the DOE Complex. Each canyon has an associated storage basin that serves as an interim staging area where reactor fuel bundles and targets await the Chemical Separations Process. The basins currently contain 13 reactor fuel assemblies (H-Area) and aluminum-clad targets (F-Area).

DOE has stored most of the remaining aluminum-clad spent nuclear fuel from SRS reactor operations under water in concrete reactor storage basins. Three reactor disassembly basins (K-, P-, and L-Reactors) contain reactor fuel and target material. These structures were built in the 1950s and were not intended for the prolonged storage of radioactive materials. Wet (underwater) storage, while potentially viable for stainless steel-clad fuel elements, is not satisfactory for aluminum-clad elements, which are subject to corrosion and pitting.

In March 1992, chemical processing operations were suspended in the canyons to address a potential safety concern. The concern was subsequently addressed but prior to resumption of processing, the Secretary of Energy directed that defense related chemical separations activities (i.e., reprocessing) be phased out at the SRS. Since the decision, DOE has determined that further action related to the disposition of nuclear material, including spent nuclear fuel, is subject to the National Environmental Policy Act (NEPA) process. Non-safety related facility operations have remained shut down with the exception of Pu-238 processing associated with the support of NASA missions.

As a result of these shut-downs, the canyons and the basins used for storage of spent nuclear fuel and irradiated targets have a large inventory of in-process solutions and fuel and targets (respectively). Some materials stored in the L- and K-Reactor disassembly basins have corroded, releasing fissile materials to the pool water. DOE is preparing an environmental impact statement that will evaluate risks that these and other SRS materials represent to the public and workers and will assess the near-term need for the actions to stabilize these materials to ensure continued safe management (DOE 1995b). These actions would take place over the short-term (about 10 years), until DOE can make programmatic decisions on disposition.

DOE stores other spent fuel in the Receiving Basin for Offsite Fuels (RBOF) on the SRS. This basin, which is in H-Area near the center of the Site, has been operating and receiving fuels of U.S. origin since 1964. This 15,000-square-foot (1,393-square-meter) facility consists of an unloading basin, two storage basins, a repackaging basin, a disassembly basin, and an inspection basin. The basins and their interconnecting transfer canals hold about 500,000 gallons (1,893,000 liters) of water. Spent fuel elements arrive in lead-lined casks weighing from 24 to 70 tons (about 22 to 64 metric tons), which a crane lifts from a railroad car or truck trailer and places in the unloading basin. About 30 percent of the fuels in the Receiving Basin for Offsite Fuels consist of uranium clad in stainless steel or Zircaloy, which SRS facilities cannot process without modifications.

2.4 Vulnerabilities Associated with SRS Spent Nuclear Fuel

In August 1993, the Secretary of Energy commissioned a comprehensive baseline assessment of the environmental, safety, and health vulnerabilities associated with the storage of spent nuclear fuel in the DOE complex. The purpose of this assessment was to determine the inventory and condition of the Department's Reactor Irradiated Nuclear Material, which includes spent nuclear fuel and reactor irradiated target material. The assessment also evaluated the condition of the facilities that store spent fuel and identified the vulnerabilities and problems currently associated with these facilities. Vulnerabilities in nuclear facilities are conditions or weaknesses that could lead to radiation exposure to the public, unnecessary or increased exposure to workers, or release of radioactive materials to the environment. Loss of institutional controls, such as a cessation of facility funding or reductions in facility maintenance and control, could cause some vulnerabilities.

Based on this evaluation process DOE released a report to the Secretary of Energy, entitled Spent Fuel Working Group Report on Inventory and Storage of the Department's Spent Nuclear Fuel and other Reactor Irradiated Nuclear Materials and Their Environmental, Safety and Health Vulnerabilities (i.e., "The Working Group Report," Volumes I, II, and III), to the public on December 7, 1993 (DOE 1993). This report identified over 100 vulnerabilities associated with spent fuel storage in the DOE complex, including 19 at the Savannah River Site. The report also determined that five facilities and three burial grounds warranted priority attention from management to avoid unnecessary increases in worker radiation exposure and cost during cleanup. The Savannah River Site L- and K-Reactor Disasssembly Basins were among these facilities. The report grouped vulnerabilities associated with each facility into three categories for management attention based on when corrective action should be initiated: less than 1 year, 1 to 5 years, and more than 5 years.

After issuing the Working Group Report, DOE developed a Plan of Action to address all vulnerabilities, taking into consideration currently available resources for implementation. The Plan of Action is a consolidation of individual action plans designed to address each spent nuclear fuel vulnerability in a manner that reflects the DOE (1) sense of urgency, (2) concern for worker protection, (3) commitment to avoid or otherwise mitigate environmental impacts, and (4) need for compatible long-term solutions.

The interim goal for the Savannah River Site reactor disassembly basins, pending completion of the removal of the stored material, is the stabilization of basin conditions to reduce corrosion and to address known vulnerabilites. The long-term goal of the action plan is a safe start of the removal of reactor-irradiated nuclear material within a 5-year period, consistent with safe and environmentally sound operations, including completion of appropriate NEPA review. These actions will lead to mitigating the identified vulnerabilities while DOE pursues other courses of action.

The 19 vulnerabilities identified for the Savannah River Site now have complete Action Plans (DOE 1994b, 1994c, 1994d). Table 2-3 lists SRS vulnerabilities by facility, tracking number, priority categorization, and Action Plan status.

DOE is currently implementing a number of the 19 Action Plans. These actions have been evaluated under the NEPA review process. The remaining corrective actions, those that will be carried out through FY99, would also undergo NEPA review prior to implementation. Only one of these outstanding actions, the construction of a dry storage facility, would likely require detailed NEPA documentation (e.g., an EIS). The construction of such a facility is addressed programmatically in this EIS as part of the Decentralization, 1992/1993 Planning Basis, Regionalization, and Centralization alternatives. Construction of new facilities would require site-specific NEPA documentation, however.

Table 2-3. SRS vulnerabilities by facility, vulnerability, tracking number, priority categorization, and Action Plan status.

Site/Facility Vulnerability Number Description	Priority Eight major facilities wit vulnerabilities	 Less than 1 year	 Greater than 1 year	Action Plan status
SRS/L-Reactor Disassembly Basin SRS-01 Potential unmonitored buildup of radionuclide or fissile materials in sand filters.	y			Complete
SRS/L-Reactor Disassembly Basin SRS-04 Lack of authorization basis in operating the sand filter cleanup system for L-Area Disassembly Basin.	y			Complete
SRS/Reactor Disassembly Basins SRS-05 Corrosion of aluminum clad fuel, targets, and components.			y	Complete
SRS/L-Reactor Disassembly Basins SRS-06 Cesium-137 activity level in L-Basin.	y			Complete
SRS/L-Reactor Disassembly Basins SRS-07 Determine whether gas bubbles release is a potential hazard above the bucket storage area at L-Reactor.	y			Complete
SRS/K-, L-, P-Reactors SRS-08 Lack of Reactor Authorization Basis.	y			Complete
SRS/K-Reactor Disassembly Basins SRS-09 Corrosion of Mark 31 A and B target slugs in K and L disassembly basins.	y			Complete
SRS/P-Reactor Disassembly Basins SRS-10 Hoist Rod Corrosion		y		Complete
SRS/K-, L-Reactor Disassembly Basins SRS-11 Reactor Disassembly Basin Safety Analysis Envelope.	y			Complete
SRS/L-Reactor Disassembly Basin SRS-12 Inadvertent flooding of L-Reactor Disassembly Basin.	y			Complete
SRS/K-Reactor Disassembly Basin SRS-13 Inadvertent flooding of K-Reactor Disassembly Basin.	y			Complete
SRS/P-Reactor Disassembly Basin SRS-14 Inadvertent flooding of P-Reactor Disassembly Basin.	y			Complete

Table 2-3. (continued).

Site/Facility	Priority Eight major

	Vulnerability Number	Description	facilities wit vulnerabilitie	Less than 1 year	Greater than 1 year	Action Plan status
SRS/RBOF; P-, R-, L-, C-, R-Reactors	SRS-15 (NOTE: RBOF is a less than 1 year vulnerability)	Conduct of operations at reactor facilities and RBOF.	y			Complete
SRS/Receiving Basin for Offsite Fuel (RBOF)	SRS-16	Inadequate tornado protection at RBOF.		y		Complete
SRS/Receiving Basin for Offsite Fuel (RBOF)	SRS-17	Seismic vulnerability of RBOF.		y		Complete
SRS/H-Area Canyon	SRS-18	Seismic vulnerability of H-Area Canyon.			y	Complete
SRS/F-Area Canyon	SRS-19	Seismic vulnerability of F-Area Canyon.			y	Complete
SRS/K-, L-, P-Reactor Disassembly Basins and RBOF	SRS-20	Inadequate leak detection system in the underground water-filled RINM storage basin.		y		Complete
SRS/L-, K-, P-Reactor Disassembly Basins	SRS-21	Inadequate seismic evaluation and potential inadequacies of structures, systems, and components to withstand a design basis event.	y			Complete

2.5 Representative Host Sites

DOE has identified two SRS areas as representative host sites for potential facilities related to the implementation of programmatic decisions on spent nuclear fuel management (Figure 2-3):

- F- and H-Areas (considered together) for the modification or expansion of existing facilities, new wet storage, and support facilities
- An undeveloped site for the construction of major new facilities, primarily an Expended Core Facility or dry storage vault.

Figure 2-3. Representative host sites on Savannah River Site. 2.5.1 F- and H-Areas

These two areas contain most of the current spent nuclear fuel facilities and operations at the SRS, including the Receiving Basin for Offsite Fuels. Therefore, DOE would focus future actions under any of the alternatives in these areas as well, for cost-effectiveness and because construction would occur in areas that had been previously disturbed.

F- and H-Areas are about 2 miles (3.2 kilometers) apart near the center of the SRS. The nearest Site boundary is approximately 7.5 miles (12 kilometers) to the west. DOE uses the land within a 5-mile (8-kilometer) radius of the two areas either for industrial purposes associated with SRS operations or as managed forest land. The closest facility to F- and H-Areas is the E-Area Solid Waste Disposal Facility, which lies between the two areas (Figure 2-3). DOE uses this facility to dispose of SRS solid low-level radioactive waste and to store TRU radioactive waste and mixed waste.

The F-Area separations facilities occupy about 420 acres (1.7 square kilometers). These facilities were designed primarily for the recovery of plutonium-239 from irradiated and unirradiated feed materials. DOE used the F-Area Canyon to dissolve target materials and produce solutions that contained the various products extracted from fission products. Further processing converted the products from solution to solid form for shipment off the Site. Large tanks in F-Area store high-level liquid radioactive waste for future stabilization and disposal through the Defense Waste Processing Facility.

H-Area facilities occupy about 395 acres (1.6 square kilometers). The H-Area Canyon processed irradiated fuel elements or target assemblies from reactors. Primary operations included the dissolution of irradiated targets and fuel tubes, chemical and physical separation, and purification of materials. DOE stores high-level liquid waste in large tanks in H-Area, as in F-Area, for future processing and disposal through the Defense Waste Processing Facility.

2.5.2 Undeveloped Representative Host Site

DOE has selected an undeveloped representative host site for the construction of new facilities that F- or H-Area could not accommodate. This site is to the south and east of H-Area, adjacent to SRS Road E and close to an existing railroad line, as shown in Figure 2-3. The SRS could make connections to existing electricity, water, and steam networks with minimal additional construction. The use of this site would have the advantage of consolidating spent nuclear fuel-related activities near F- and H-Areas and close to the center of the SRS.

This site is representative of many available areas on the SRS that could support spent nuclear fuel management activities. For example, DOE has identified a different representative site for the possible construction of the Expended Core Facility for the management of naval spent nuclear fuel (see Appendix D of Volume 1 of this Environmental Impact Statement). DOE would conduct a detailed siting analysis before implementing any programmatic decision at the SRS. DOE would assess, as necessary, the environmental consequences of the siting of any facilities as part of the site-specific NEPA documentation.

3. SPENT NUCLEAR FUEL ALTERNATIVES

This chapter describes the five management alternatives for spent nuclear fuel that the U.S. Department of Energy (DOE) has evaluated for the Savannah River Site (SRS) as part of Volume 1 of this Environmental Impact Statement. These alternatives are:

1. No Action
2. Decentralization
3. 1992/1993 Planning Basis
4. Regionalization (with 2 subalternatives for the SRS)
5. Centralization (with 2 subalternatives for the SRS)

The activities covered by the alternatives range from maintaining the current inventory of spent fuel at the SRS without receiving any more shipments (Alternative 1), through keeping the existing inventory and accepting or sending off some limited shipments (Alternatives 2 through 4), to receiving at the Site all DOE spent nuclear fuel and some from other sources (Alternative 5). DOE also examined an option for shipping all spent nuclear fuel at the SRS to another location (a variation of Alternatives 4 and 5). Table 3-1 summarizes the quantities of material that would be received, shipped out, and ultimately managed at the SRS under the various alternatives. DOE has assessed the aluminum-clad spent nuclear fuel separately from nonaluminum-clad fuel (i.e., stainless steel and Zircaloy) because the options for managing them at the Site could be different as explained in Section 3.1.

The analytical approach used in this document produces estimates of consequences that would be as large as or larger than any that could occur or be expected under the alternatives and provides a comparison of the impacts of the principal technologies for managing spent nuclear fuel at the SRS.

This chapter also provides an overview of the SRS management approach and describes the five alternatives as they relate to the SRS (Sections 3.1 and 3.2). In addition, the chapter summarizes and compares the potential environmental consequences of each alternative (Section 3.3).

Table 3-1. Quantities (MTHM)a of spent nuclear fuel that would be received, shipped, and managed at the SRS under the five alternatives.b,c

Alternative	Fuel Type	Currently at SRS	Receive	Ship Out	Totals managed at SRS under this

					alternative
1. No Action	Aluminum	184.40	0.00	0.00	184.40
	Nonaluminum	21.87	0.00	0.00	21.87
	Totals	206.27	0.00	0.00	206.27
2. Decentralization	Aluminum	184.40	11.02	0.00	195.42
	Nonaluminum	21.87	2.60	0.00	24.47
	Totals	206.27	13.62	0.00	219.89
3. 1992/1993 Planning Basis	Aluminum	184.40	13.69	0.00	198.09
	Nonaluminum	21.87	2.80	0.00	24.67
	Totals	206.27	16.49	0.00	222.76
4. Regionalization - A	Aluminum	184.40	28.69	0.00	213.09
(by fuel type)	Nonaluminum	21.87	0.00	(21.87)	0.00
	Totals	206.27	28.69	(21.87)	213.09
4. Regionalization - B	Aluminum	184.40	19.93	0.00	204.33
(by location at SRS)	Nonaluminum	21.87	30.42	0.00	52.29
	Totals	206.27	50.35	0.00	256.62
4. Regionalization - B	Aluminum	184.40	0.00	(184.40)	0.00
(by location, elsewhere)	Nonaluminum	21.87	0.00	(21.87)	0.00
	Totals	206.27	0.00	(206.27)	0.00
5. Centralization	Aluminum	184.40	28.69	0.00	213.09
(at SRS)	Nonaluminum	21.87	2,506.84	0.00	2,528.71
	Totals	206.27	2,535.53	0.00	2,741.80
5. Centralization	Aluminum	184.40	0.00	(184.40)	0.00
(elsewhere)	Nonaluminum	21.87	0.00	(21.87)	0.00
	Totals	206.27	0.00	(206.27)	0.00

a. To convert metric tons of heavy metal to tons, multiply by 1.1023.
b. Numbers may not sum due to rounding.
c. Source: Wichmann (1995).

3.1 SRS Management Approach

3.1.1 Management Options

DOE has evaluated three options for the management of spent nuclear fuel at the SRS under the five alternatives considered for this EIS. These technical management options are wet storage or dry storage of all fuels and the processing of aluminum-clad fuels. DOE could implement these options individually or in combination under any of the five alternatives. DOE would base its selection of one or more of these technical management options on additional analysis, including a separate SRS-specific National Environmental Policy Act (NEPA) review based on this programmatic EIS.

3.1.1.1 Wet Storage. As described above in Section 2.3, the SRS currently maintains its

spent nuclear fuel in wet storage in the Receiving Basin for Offsite Fuels and several reactor basins. Wet storage under the 40-year interim management plan (except under the No Action alternative) would require that DOE construct a new wet storage pool at the SRS and move all fuel to this facility. Prior to this transfer, DOE could place all the aluminum-clad fuel in stainless steel canisters to prevent further corrosion and breakdown of the fuel cladding. The stainless steel- and Zircaloy-clad fuels could also require canning. The SRS would monitor and maintain the water quality and the condition of the fuel in the storage pool throughout the interim management period.

Under this wet storage option, the spent nuclear fuel would be in an interim storage form, which could require further treatment depending on the DOE decision on its ultimate disposition.

3.1.1.2 Dry Storage. DOE currently has no dry storage facilities for spent nuclear fuel at the

Site. Dry storage of SRS aluminum-clad fuels under this management plan would require technology development prior to the construction of a dry storage facility. Although such facilities exist at other DOE sites and at commercial locations, DOE believes that the characteristics of SRS spent fuel are sufficiently different to require some research and development before the design and construction of a facility for this fuel. DOE would can all fuel before placing it into the dry storage vaults. It would also have to maintain and monitor the facility for the remainder of the 40-year management period.

As with wet storage, the dry storage option would place the spent fuel into an interim storage form that could require further treatment later depending upon DOE's decision on ultimate disposition.

3.1.1.3 Processing and Dry Storage. One method under this option would be for the SRS to process existing aluminum-clad spent nuclear fuel through the existing separations facilities in the F- and H-Area Canyons, and place the nonaluminum-clad fuels and any future receipts in dry storage. The process using existing capability would result in the generation of both separated actinides (e.g., uranium oxide), which would be stored on the site in existing facilities, and solutions of fission products that would be placed in existing waste storage facilities for later conversion to a glassified form through the Defense Waste Processing Facility (DWPF). DOE would maintain and monitor the dry storage facility containing the nonaluminum-clad spent fuel. Variations of this processing option are also possible, such as processing all the aluminum-clad fuel currently on the Site plus all that is received from elsewhere, or developing the capability at the SRS for processing for vitrification without chemical separations.

The process option selected for evaluation in this document is representative of possible processing options that might be employed, but is not necessarily the one that DOE would select. Detailed NEPA evaluations would be required to implement any spent nuclear fuel management plan at the SRS.

3.1.2 Management Plan

Figure 3-1 summarizes DOE's overall plan for the interim management of aluminum-clad and nonaluminum-clad fuels at the SRS. This flowchart shows actions for all alternatives except No Action, as explained in Section 3.2.1.

3.1.2.1 Aluminum-clad Fuels. Depending on the alternative and option selected, DOE could (within constraints of mission commitments) consolidate some aluminum-clad fuel in the Receiving Basin for Offsite Fuels to take advantage of this facility's superior water quality and then move all aluminum-clad fuel into dry storage, wet storage, or initiate processing (Figure 3-1). DOE could also process aluminum-clad fuel without any consolidation work. Before moving the fuel into dry or wet storage, DOE would place it in cans. DOE would hold the canned fuel or the stabilized products from processing in storage for the 40-year interim management period until it decided their final disposition.

DOE would place aluminum-clad fuels received by the SRS from other locations in wet or dry storage. DOE could not implement any of the options for aluminum-clad fuels, with the exception of processing using existing SRS capabilities, without a technology development effort.

3.1.2.2 Nonaluminum-clad Fuels. DOE options for the management of nonaluminum-clad fuels at the SRS are somewhat different, in that only dry or wet storage is considered (Figure 3-1). The processing of these fuels at the Site is not an option because the SRS does not currently have operational facilities capable of separating these materials. To improve aluminum-clad fuel storage, DOE could consolidate the nonaluminum-clad fuel inventory in a reactor basin where the more resistant stainless steel or Zircaloy cladding would be less susceptible to corrosion. The fuel would remain there until DOE built new dry or wet storage facilities. DOE would then can the fuel and move it into the new storage. DOE would place any nonaluminum-clad fuel received at the SRS after completion of the new facilities directly into storage. The fuel would remain in this interim storage until DOE decided its ultimate disposition.

Figure 3-1. Diagram of how SRS would manage aluminum-clad and nonaluminum-clad fuels. "Near-term Receipts" refers to the fuel that would be received before new wet or dry storage facilities are available.

3.2 Description of Alternatives

3.2.1 Overview

Table 3-2 compares actions under each of the five alternatives. These actions relate to the requirements for transportation, stabilization, facilities, and research and development that DOE would address for each alternative. Transportation would include onsite movements as well as the receipt or shipment of spent fuel. The consideration of facilities addresses not only new ones that could be required, but also the use of existing structures and capabilities such as the F- and H-Area Canyons at SRS. Finally, each alternative would involve some level of research and development on matters related to spent nuclear fuel interim management (e.g., stabilization, transportation casks) and its ultimate disposition.

Alternative 1 (No Action) addresses only the interim wet storage option, while the analysis of Alternatives 2 through 5 considers three options: dry storage, wet storage, and processing of existing aluminum-clad fuels and placing the other fuels into storage. In addition, Alternatives 4 and 5 include an option for the shipment of spent nuclear fuel off the SRS. This analytical approach shows the relative impact of viable interim storage technologies for the range of alternatives this EIS is considering for the SRS. However, this information is not sufficient to support the selection of a specific interim storage technology at the SRS because DOE has not completed site-specific research and development for dry storage and wet storage methods or an evaluation of other processing options. In addition, the specific quantities of offsite fuel that DOE would manage are subject to change. The selection of an interim storage technology will be the subject of separate NEPA documentation specific to the SRS.

Figure 3-2 is a matrix showing the types of facilities that would be required for each alternative and option. The list includes those facilities already operating at the SRS (e.g., Receiving Basin for Offsite Fuels) as well as potential facilities (e.g., fuel characterization facility). DOE considered these facilities in its evaluation of the consequences of each alternative, as described in Chapter 5.

The alternatives described below address interim storage to 2035; further treatment of the spent nuclear fuel would be necessary before DOE obtained a final disposable waste form. This EIS does not address this additional treatment. However, DOE would carry out a full NEPA documentation for any decision on final disposition of spent nuclear fuel.

Table 3-2. Actions required under each of the five alternatives at the SRS.

Alternative	Transportation	Stabilization	Facilities	Research and Development
1. No Action	No shipments to or from the Site. Limit onsite transfers to those required for safe storage.	Place aluminum-clad fuels that are badly corroded and in danger of cladding failure in containers and return them to wet storage.	Store fuels in Receiving Basin for Offsite Fuels and in an upgraded reactor basin. Requires no new facilities.	Continue existing spent nuclear fuel-related research and development.

2. Decentralization   Receive about 13.6 MTHM (15.0   Can aluminum-clad fuels and
Store fuels in Receiving Basin for   Develop technology (canning
                        tons) of aluminum-clad and   place them in wet or dry
Offsite Fuels or upgraded reactor   and storage design) to store SRS
                        nonaluminum-clad fuels. Limit   storage or process existing fuel
basin until new wet or dry storage   aluminum-clad fuels in dry
                        onsite transfers to those required   through F- and H-Canyons.
facility is built. Requires new   storage vault. Conduct research
                        for safe storage, consolidation,   Can stainless-steel and
characterization facility, new wet   and pilot-scale operations to
                        and research and development.   Zircaloy fuels and place in wet
or dry canning facility, and new   determine best technology for
                        Later relocate fuels to new wet or   or dry storage.
wet or dry storage facility.   ultimate disposition of
                        dry storage facility or move
aluminum-clad fuels.
                        aluminum-clad fuels to F- and
                        H-Canyons for processing.
3. 1992/1993 Planning   Receive about 16.5 MTHM (18.2   Can aluminum-clad fuels and
Store fuels in Receiving Basin for   Develop technology (canning
   Basis   tons) of aluminum-clad and   place them in wet or dry
Offsite Fuels or upgraded reactor   and storage design) to store SRS
                        nonaluminum-clad fuels. Limit   storage or process existing fuel
basin until new wet or dry storage   aluminum-clad fuels in dry
                        onsite transfers to those required   through F- and H-Canyons.
facility is built. Requires new   storage vault. Conduct research
                        for safe storage, consolidation,   Can stainless steel and
characterization facility, new wet   and pilot-scale operations to
                        and research and development.   Zircaloy fuels and place in wet
or dry canning facility and new   determine best technology for
                        Later relocate fuels to new wet or   or dry storage.
wet or dry storage facility.   ultimate disposition of
                        dry storage facility, or move
aluminum-clad fuels.
                        aluminum-clad fuels to F- and H-
                        Canyon for processing.
4. Regionalization - A Receive about 28.7 MTHM (31.6   Can aluminum-clad fuels and
Store fuel in existing Receiving   Develop technology (canning
 (by fuel type at the   tons) of aluminum-clad fuel.   place them in wet or dry
Basin for Offsite Fuels or   and storage design) to store
 SRS)   Ship to Idaho National   storage; or process existing
upgraded reactor basin until new   aluminum-clad fuels in dry
                        Engineering Laboratory about   fuel through F- and
wet or dry storage facility is   storage vault. Conduct research
                        21.9 MTHM (24.1 tons) of   H-Canyons.
available, or until fuel is   and pilot-scale operations to
                        stainless steel and Zircaloy fuel.
processed. Requires new receiving   determine best technology for
                        Relocate aluminum-clad fuels to
and characterization facilities, new   ultimate disposition of
                        Receiving Basin for Offsite
wet or dry canning facilities, and   aluminum-clad fuels.
                        Fuels, as necessary; then to new
new wet or dry storage facilities.
                        wet or dry storage facilities, or
                        move aluminum-clad fuels to F-
                        and H-Canyon for processing.
4. Regionalization - B Receive approximately 50.4   Can aluminum-clad fuels and
Store fuels in Receiving Basin for   Develop technology (canning
 (by location at the   MTHM (55.6 tons) of spent fuel   place them in wet or dry
Offsite Fuels or upgraded reactor   and storage design) to store SRS
 SRS)   from other locations. Limit   storage; or process existing
basin until new storage facility is   aluminum-clad fuels in dry
                        onsite transfers to those required   aluminum-clad fuels through
available. Store new fuel   storage vault. Conduct research
                        for safe storage, consolidation,   F- and H-Canyons and store
shipments in new wet or dry   and pilot-scale operations to
                        and research and development.   remaining fuel. Characterize
storage facility. Requires new   determine best technology for
                        Relocate fuels to new dry or wet   and can fuel received from
receiving, characterization and   ultimate disposition of
                        storage facility or move   offsite that is not in a form
canning facilities, new wet or dry   aluminum-clad fuels.
                        aluminum-clad fuel to F- and   suitable for direct placement
storage facility, and possibly a new
                        H-Canyons for processing.   into storage.
Expended Core Facility.
4. Regionalization - B Move all fuels to new   Characterize and can all spent
Store existing fuels in Receiving   Develop technology for
 (by location   characterization facility prior to   fuel prior to shipment.
Basin for Offsite fuel and in a   stabilization, canning, and

at another site)   shipment offsite. Ship out about
reactor basin until characterization   shipment of degraded aluminum-
206.3 MTHM (227.4 tons) of
and shipment offsite. Requires   clad fuel.
spent fuel.
new characterization facility.
5. Centralization (at   Receive about 2,535.5 MTHM   Can aluminum-clad fuels and
Store fuel in Receiving Basin for   Develop technology (canning
the SRS)   (2,794.9 tons) of spent fuel from   place them in wet or dry
Offsite Fuels or in an upgraded   and storage design) to store SRS
offsite. Limit onsite transfers to   storage; or process existing
reactor basin until new storage   aluminum-clad fuels in dry
those required for safe storage,   aluminum-clad fuels through
facilities are available. Store new   storage vault. Conduct research
consolidation, and research and   F- and H-Canyons and store
fuel shipments in new wet or dry   and pilot-scale operations to
development. Relocate fuels to   remaining fuels. Characterize
storage facility. Requires new   determine best technology for
new dry or wet storage facility or   and can fuel received from
receiving, characterization and   ultimate disposition of spent
move aluminum-clad fuel to F-   offsite that is not in a form
canning facilities, new wet or dry   nuclear fuels.
and H-Canyons for processing.   suitable for direct placement in
storage facility, and new Expended
storage.
Core Facility.
5. Centralization (at   Move all fuels to new   Characterize and can all spent
Store existing fuel in Receiving   Develop technology for
another site)   characterization facility prior to   fuel prior to shipment.
Basin for Offsite Fuel or in an   stabilization, canning, and
shipment offsite. Ship out about
upgraded reactor basin until   shipment of degraded aluminum-
206.3 MTHM (227.4 tons) of
characterization and shipment   clad fuel.
spent fuel.
offsite. Requires new

characterization facility.

Figure 3-2. Types of facilities required for each alternative. 3.2.2 Alternative 1 - No Action

3.2.2.1 Overview. This alternative deals only with the minimum actions that DOE would

deem necessary for the continued safe and secure management of spent nuclear fuel. It is not a status quo condition. Rather, across its complex of facilities, DOE would maintain spent nuclear fuel close to generation or current storage locations with no shipment between sites. Facility upgrades or replacements and onsite fuel transfers would occur only to support safe and secure interim storage.
DOE would continue existing and new research and development activities for spent fuel interim management. Stabilization activities would be limited only to those minimum actions required to store spent nuclear fuel safely.

3.2.2.2 SRS Alternative 1 - Wet Storage. DOE would initiate the various SRS programs

and activities necessary to obtain optimum use of existing spent nuclear fuel facilities for the extended storage of existing Site inventories totalling 206.3 metric tons (227.4 tons) of heavy metal (MTHM) in the following quantities:

- 184.4 MTHM (203.3 tons) of Savannah River Defense Production [highly enriched uranium (HEU) aluminum-clad fuels], including plutonium target material, and other aluminum-clad fuels
- 4.6 MTHM (5.1 tons) of commercial spent nuclear fuel (primarily zirconium-clad)
- 5.4 MTHM (6.0 tons) of test and experimental reactor stainless steel-clad fuel
- 11.9 MTHM (13.1 tons) of test and experimental reactor Zircaloy-clad fuel

The goal of this program would be to relocate some aluminum-clad fuels to the Receiving Basin for Offsite Fuels where precisely maintained water quality would prolong the storage life of these fuel types. In addition, DOE would relocate a portion of the stainless steel- and Zircaloy-clad fuels to a reactor basin, where their more resistant cladding would maintain fuel containment for an extended period. These actions would be accomplished within the constraints of mission requirements.

The following describes one method that could be employed to improve the storage of aluminum-clad fuel. Variations of this plan that would involve only the use of existing storage basins are also possible.

- Select a reactor basin for upgrading and for the interim storage of SNF.
- Relocate aluminum-clad fuels from the selected reactor basin to other onsite basins to enable cleaning and repair of the basin chosen for upgrade to improve water quality.
- Consolidate fuels in the Receiving Basin for Offsite Fuels to the extent possible.
- After cleaning and renovating the selected reactor basin, move a portion of the stainless steel and Zircaloy-clad fuel assemblies now at the Receiving Basin for Offsite Fuels to the renovated reactor basin.
- Move the aluminum-clad fuels temporarily stored at other locations to the Receiving Basin for Offsite Fuels or the renovated reactor basin.

DOE will continue to place heavily corroded aluminum-clad fuel elements that could be in danger of cladding failure into containers in the wet pool as required to minimize any spread of materials throughout the pool. This action would be much simpler than canning the elements, which would occur under the other alternatives.

This alternative would require no new facilities. DOE would continue existing spent nuclear fuel-related research and development.

3.2.3 Alternative 2 - Decentralization

3.2.3.1 Overview. Under this alternative, DOE would maintain existing spent nuclear fuel in

storage at the current locations, and the SRS would receive some shipments of university fuel and foreign fuel. This alternative differs from the No Action alternative by allowing significant facility development and upgrades. DOE could transport fuel on the Site for safety, fuel consideration, or research and development activities. In addition, DOE could undertake actions it deemed desirable, though not essential, for safety and could perform spent nuclear fuel processing, treatment, research, and development.

3.2.3.2 SRS Options 2a, 2b, and 2c. DOE analyzed three options specific to the SRS for

this alternative: Option 2a deals with dry storage, Option 2b deals with wet storage, and Option 2c involves processing existing SRS aluminum-clad spent nuclear fuel and storing the remaining fuel. The amount of spent fuel that the SRS would manage includes its current inventory, as described above for Alternative 1, plus:

- 11.0 MTHM (12.0 tons) of aluminum-clad fuel
- 1.1 MTHM (1.2 tons) of stainless steel-clad fuel
- 0.7 MTHM (0.8 ton) of Zircaloy-clad fuel
- 0.8 MTHM (0.9 ton) of other experimental fuel

Under this alternative, SRS would manage a total of about 219.9 MTHM (242.4 tons) of spent nuclear fuel. The SRS would receive spent fuel from research reactors as existing storage allowed and as new storage was constructed.

3.2.3.2.1 Option 2a - Dry Storage - Under this option, DOE would store existing SRS

inventories in wet pools while developing the technology and constructing the necessary facilities to examine, characterize, and can the fuels and transfer them to a new dry storage vault to await treatment for final disposition.
The SRS would proceed with the fuel rearrangement plan described above for Alternative 1 to provide acceptable storage conditions to minimize failures of the aluminum-clad material before its placement in a dry-storage container.

Placement in a dry-storage facility would require a technology development program into DOE capabilities to examine, characterize, and can aluminum-clad fuel elements before placing them in a vault. In addition, the SRS would investigate technologies for the ultimate disposition of spent nuclear fuel. In addition to a dry storage facility, the SRS would build new fuel receiving, characterization, and dry canning facilities.

3.2.3.2.2 Option 2b - Wet Storage - Under this option, DOE could rearrange existing

spent nuclear fuel as described above for Alternative 1 to provide interim wet storage capacity while constructing new facilities. SRS could also modify this rearrangement plan to accept shipments of spent fuel from offsite and place them directly into the Receiving Basin for Offsite Fuels, as circumstances warrant. The new wet storage facilities required under this option would include the capability to examine and characterize fuels and to can deteriorating fuels in a stainless steel package for placement in the new pool. DOE would move all fuel to the new storage pool once it was complete. SRS would build new fuel receiving, characterization, and wet-canning facilities as well as a new wet storage pool. SRS would investigate technologies for the ultimate disposition of spent nuclear fuel.

3.2.3.2.3 Option 2c - Processing and Storage - Under this option, SRS would

process existing aluminum-clad spent nuclear fuel to consolidate and stabilize the nuclear material for storage in vaults, and would place the stainless steel- and Zircaloy-clad fuel and new receipts of aluminum-clad fuel in dry storage. The fuel would remain in the current wet pools while awaiting processing or the construction of new dry storage facilities. DOE would use existing F- and H-Area facilities to process the aluminum-clad fuel to safe, stable, consolidated forms.

The new facilities that the SRS would require under this option would be similar to those described for dry storage (Option 2a), except they would be much smaller because the amount of fuel to be stored would be small: only about 11.0 MTHM (12.0 tons) of aluminum-clad and about 24.5 MTHM (27.0 tons) of nonaluminum-clad fuel. The SRS would investigate technologies required for the ultimate disposition of spent fuel.

3.2.4 Alternative 3 - 1992/1993 Planning Basis

3.2.4.1 Overview. This alternative assumes the continued transportation, receipt, processing,

and storage of spent nuclear fuel. Foreign and university research reactor spent nuclear fuel would be sent to the INEL and the SRS. DOE would assess the construction of new facilities required to accommodate current and projected spent nuclear fuel storage requirements. This alternative would include activities related to the treatment of spent nuclear fuel, including research and development and pilot programs to support future decisions on its ultimate disposition.

3.2.4.2 SRS Options 3a, 3b, and 3c. DOE analyzed the same three options for this

alternative as for Alternative 2: dry storage (Option 3a), wet storage (Option 3b), and the processing of existing SRS aluminum-clad fuel and storing the remaining fuel (Option 3c). The quantities of fuel would be somewhat greater than those for Alternative 2 because the options assume that the SRS would manage its present inventory (see Alternative 1) plus approximately:

- 13.7 MTHM (15.1 tons) of aluminum-clad fuel
- 1.3 MTHM (1.4 tons) of stainless steel-clad fuel
- 0.7 MTHM (0.8 ton) of Zircaloy-clad fuel
- 0.8 MTHM (0.9 ton) of other experimental fuel
- a small amount (<0.1 ton) of commercial nonaluminum-clad fuel

The total spent nuclear fuel managed would equal about 222.8 MTHM (245.6 tons). The Site would receive shipments of fuel from other locations as existing space allowed and as new facilities were completed.

3.2.4.2.1 Option 3a - Dry Storage - The Site would store current inventories in

existing wet pools while developing technology and constructing facilities necessary to examine, characterize, and can the fuels and transfer them to a new dry storage vault to await treatment for final disposition.

The actions that SRS would undertake under this option and the new facilities to be constructed would be the same as those described for Option 2a - Dry Storage under Alternative 2 (Decentralization) in Section 3.2.3.2.1.

3.2.4.2.2 Option 3b - Wet Storage - DOE could rearrange existing spent nuclear fuel

as described in Alternative 1 above to provide interim wet storage capacity while building new facilities. The Site could also accept new shipments directly into the Receiving Basin for Offsite Fuels, as required. The actions that SRS would undertake under this option, and the new facilities to be constructed, would be the same as those described for Option 2b - Wet Storage under Alternative 2 (Decentralization) in Section 3.2.3.2.2.

3.2.4.2.3 Option 3c - Processing and Storage - Under this option, the SRS would

process existing aluminum-clad spent nuclear fuel and would place the stainless steel- and Zircaloy-clad fuel and new receipts of aluminum-clad fuel in storage as described for Option 2c - Processing under Alternative 2 (Decentralization) in Section 3.2.3.2.3. The requirements for new facilities and for technology development would also be the same.

3.2.5 Alternative 4 - Regionalization

3.2.5.1 Overview. This alternative has two subalternatives. The first (Regionalization A)

would involve the distribution of existing and new spent nuclear fuel among DOE sites based primarily on the similarity of fuel type, although DOE would also consider transport distances, available processing capabilities, available storage capabilities, or a combination of these factors. Under this subalternative, SRS would receive all aluminum-clad fuel and would transfer its existing inventory of stainless steel- and Zircaloy-clad fuel to another DOE site. The SRS would manage a total of about 213.1 MTHM (234.9 tons) of spent fuel under the Regionalization A subalternative.

The second subalternative (Regionalization B) would require DOE to consolidate all existing and new spent fuel at two sites - one to the east of the Mississippi River and one to the west - depending on the location or generation site of the fuel. Under this alternative, the SRS would either receive all spent nuclear fuel in the east [approximately 256.6 MTHM (282.9 tons)] or ship its current inventory offsite to the Oak Ridge Reservation in Tennessee. An additional option if SRS becomes the Eastern Regional Site is for DOE to construct an Expended Core Facility at the SRS to manage some Naval fuel. This option is described in Appendix D of Volume 1 of this EIS.

Under either subalternative, DOE would undertake facility upgrades, replacements, and additions as appropriate. This alternative would include research and development and pilot programs to support current management and future decisions on spent fuel disposition.

3.2.5.2 SRS Options 4a, 4b, and 4c (Regionalization A). DOE analyzed three options

for the regionalization of fuels by fuel type: dry storage (Option 4a), wet storage (Option 4b) and processing of existing SRS aluminum-clad fuels and storing the remaining fuel (Option 4c). This subalternative assumes that the SRS would manage:

- Its current inventory of 184.4 MTHM (203.3 tons) of aluminum-clad fuels, plus
- Approximately 28.7 MTHM (31.6 tons) of research reactor aluminum-clad fuel from other sites

The SRS would ship to the Idaho National Engineering Laboratory approximately:

- 5.4 MTHM (6.0 tons) of stainless steel-clad fuel
- 4.6 MTHM (5.1 tons) of commercial nonaluminum-clad fuel
- 11.9 MTHM (13.1 tons) of Zircaloy-clad spent fuel

DOE would manage a total of about 213.1 MTHM (234.9 tons) of spent nuclear fuel at the SRS under this subalternative. The site would receive shipments from other locations as existing space became available and as it shipped the nonaluminum-clad fuel.

3.2.5.2.1 Option 4a - Dry Storage - The actions that the SRS would undertake under

this option, and the new facilities to be constructed, would be the same as for those described for Option 2a - Dry Storage under Alternative 2 (Decentralization) in Section 3. 2.3.2.1.

This option would require an extensive research and development program into capabilities to examine, characterize, and can the SRS aluminum-clad fuel for dry storage.

3.2.5.2.2 Option 4b - Wet Storage - The SRS would carry out the same actions and

construct the same types of facilities under this option as it would for Option 2b - Wet Storage under Alternative 2 (Decentralization) as described in Section 3. 2.3.2.2. Research and development activities would also be similar to those conducted under this Decentralization alternative, except the SRS would not perform studies on nonaluminum-clad fuels.

3.2.5.2.3 Option 4c - Processing and Storage - Under this option, the SRS would

process the existing aluminum-clad fuel as described for Option 2c - under Alternative 2 (Decentralization) and place the aluminum-clad fuel received from offsite into wet storage. The requirements for new construction would be different than in Option 2c, in that dry storage facilities would not be required because the nonaluminum-clad fuels would be shipped off the site. The small amount of aluminum-clad fuel to be received could be more readily stored in pools rather than developing new dry storage. Therefore, Option 4c would require DOE to construct a new fuel receiving, wet canning and wet storage facility to manage the fuel received after the major processing operations are completed. These facilities would be much smaller than those required for other alternatives.

3.2.5.3 SRS Options 4d, 4e, 4f, and 4g (Regionalization B). DOE analyzed the same

three options for the regionalization of spent fuel on the basis of geographic location as for the other alternatives: dry storage (Option 4d), wet storage (Option 4e), and processing of existing aluminum-clad fuel and storing the remaining fuel (Option 4f). In addition, it assessed the option of shipping all SRS inventory offsite (Option 4g).

The amount of material that the SRS would manage if all the spent fuel in the East were shipped to the Site would total about 256.6 MTHM (282.9 tons). This would include the current SRS inventory of about 206.3 MTHM (227.4 tons) as detailed in Section 3.2.2 plus:

- 19.9 MTHM (21.9 tons) of aluminum-clad fuel
- 26.7 MTHM (29.4 tons) of commercial nonaluminum-clad fuel
- 1.0 MTHM (1.1 ton) of stainless steel-clad fuel
- 1.3 MTHM (1.4 tons) of experimental Zircaloy-clad fuel
- 1.4 MTHM (1.5 tons) of other experimental fuel

The activities that DOE would have to undertake at the SRS, and the facilities that it would have to build, under the dry storage, wet storage, or processing options would be very similar to those required for the Decentralization alternative (Section 3.2.3). The difference would be that the size of the storage facilities would be somewhat greater because the amount of fuel to be managed would be larger [256.6 MTHM (282.9 tons) versus 219.9 MTHM (242.4 tons)]. In addition, DOE would conduct additional research and development on the other fuel types that SRS would manage under these options.

3.2.5.3.1 Option 4d - Dry Storage - The actions that the SRS would undertake under

this option, and the new facilities to be constructed, would be similar to those described for Option 2a - Dry Storage under Alternative 2 (Decentralization) in Section 3.2.3.2.1. This option would require an extensive research and development program into capabilities to examine, characterize, and can the SRS aluminum-clad fuel for dry storage.

3.2.5.3.2 Option 4e - Wet Storage - The SRS would carry out the same actions and

construct the same types of facilities under this option as it would for Option 2b - Wet Storage under Alternative 2 (Decentralization) as described in Section 3.2.3.2.2. Research and development activities would also be similar to those conducted under this Decentralization alternative.

3.2.5.3.3 Option 4f - Processing and Storage - Under this option, the SRS would

process the existing aluminum-clad fuel and place nonaluminum-clad fuel and aluminum-clad fuel received from offsite in dry storage as described for Option 2c - Processing with storage under Alternative 2 (Decentralization). The requirements for new facilities and for research and development would also be similar.

3.2.5.3.4 Option 4g - Shipment Off the Site - Under this option, the SRS would ship

its current inventory of about 206.3 MTHM (227.4 tons) to the Oak Ridge Reservation. The activities and facilities required for this option are the same as those described below for Option 5d of the Centralization alternative (Section 3.2.6.2.4).

3.2.6 Alternative 5 - Centralization

3.2.6.1 Overview. Under this alternative, DOE would collect all current and future spent

nuclear fuel inventories from DOE sites, the Navy, and other sources at a single location for management until final disposition. DOE would construct new facilities at the centralized site to accommodate the increased inventories. The originating sites would characterize and stabilize their spent nuclear fuel before shipping. They would then close their spent fuel facilities. This alternative would include the centralization of activities related to the treatment of spent nuclear fuel, including research and development and pilot programs to support future decisions on its disposition.

3.2.6.2 SRS Options 5a, 5b, 5c, and 5d. DOE analyzed four options for this alternative.

Three deal with shipping all DOE spent nuclear fuel to the SRS for disposition and management in dry storage (Option 5a), wet storage (Option 5b), or by processing existing aluminum-clad fuel and storing the remaining fuel (Option 5c). The fourth case involves the shipment of all SRS fuel off the Site to another location (Option 5d). Options 5a, 5b, and 5c concern the following fuels:

- 65.2 MTHM (71.7 tons) of naval fuel
- 213.1 MTHM (234.9 tons) of aluminum-clad fuel
- 2103.2 MTHM (2,318.4 tons) of Hanford defense fuel
- 27.6 MTHM (30.4 tons) of graphite fuel
- 156.5 MTHM (172.5 tons) of commercial nonaluminum-clad fuel
- 96.5 MTHM (106.4 tons) of experimental stainless steel-clad fuel
- 78.0 MTHM (86.0 tons) of Zircaloy-clad fuel
- 1.7 MTHM (1.9 tons) of other fuel types

DOE would manage a total of about 2,741.8 MTHM (3,022.3 tons) of spent nuclear fuel at the SRS under the first three options. Options 5a and 5b would involve storing all the fuel on the Site.
Option 5c would require processing the existing aluminum-clad fuel [184.4 MTHM (203.3 tons)] and placing the remaining nonaluminum-clad SRS fuels and all fuel received from other locations [2,557.4 MTHM (2,819.0 tons)] into dry storage. The SRS could accept shipments from offsite sources and place them in storage as it built new facilities and transferred the onsite inventory.

Under Option 5d, shipments leaving the Site would amount to about 206.3 MTHM (227.4 tons), which is equal to the inventory of spent nuclear fuel at the SRS under Alternative 1.

3.2.6.2.1 Option 5a - Dry Storage - The actions that the SRS would undertake under

this option would be the same as those described for Option 2a - Dry Storage under Alternative 2 (Decentralization) in Section 3.
2.3.2.1. However, the number and size of the new facilities needed to implement this centralization option would be much greater because of the larger volume of fuel that the Site would manage. In addition, DOE would have to build a new Expended Core Facility at the SRS to examine and characterize the naval fuels.

This option would require an extensive research and development program into capabilities to examine, characterize, and can SRS and other fuel types before their placement in a dry storage vault.
DOE would also carry out research and development into other aspects of the management of the spent fuels, including those related to its ultimate disposition.

3.2.6.2.2 Option 5b - Wet Storage - Under this option, DOE would undertake actions

similar to those described in Section 3.
2.3.2.2 for Option 2b - Wet Storage under Alternative 2. As with Option 5a (Dry Storage), the SRS would have to build major new facilities to manage the large volume of fuel it would receive. DOE would also have to build a new Expended Core Facility at the SRS. Research and development would be greatly expanded as well.

3.2.6.2.3 Option 5c - Processing and Storage - DOE would process the current

inventory of aluminum-clad spent fuel under this option in the same manner as described for the other alternatives.
All other fuel onsite and all fuel received from elsewhere would be canned and placed in new dry storage facilities. The SRS would shut down the F- and H-Area separations facilities after processing the existing inventory of aluminum-clad fuel. Thereafter, any aluminum-clad fuel sent

to the SRS would be placed in dry storage.

This option would require major new facilities, including a new Expended Core Facility. DOE would also conduct extensive research and development in spent fuel management.

3.2.6.2.4 Option 5d - Shipment Off the Site - DOE would consolidate and prepare

all spent nuclear fuel on the SRS for shipment to another DOE site; this would require the construction of a new fuel characterization facility. Some fuels could require canning before shipment. SRS would use existing facilities to accomplish this. DOE would then close all SRS spent nuclear fuel-related facilities.

DOE would conduct research and development into methods of stabilizing, canning, and transporting aluminum-clad fuels, particularly that which is corroded or otherwise degraded.

3.3 Comparison of Alternatives

Table 3-3 summarizes the environmental consequences of the five alternatives. Chapter 5 presents detailed descriptions of these consequences.

In general, the levels of impacts associated with Alternatives 1 through 4 would be similar because the amounts of spent nuclear fuel that DOE would manage at the SRS under these cases would be approximately the same [e.g., about 206 to 257 MTHM (227 to 283 tons)] and activities would extend throughout the full 40-year management period. The lowest level of impact at SRS would occur under Option 4g or Option 5d (Regionalization or Centralization at another site) because DOE would ship the SRS spent fuel off the Site well before the management period ended in 2035. Alternative 5, under which DOE would ship all spent nuclear fuel to the SRS, would result in the greatest onsite impacts; the Site would have to manage approximately 2,741.8 MTHM (3,022.3 tons) of spent fuel.

Table 3-3. Comparison of impacts for the five alternatives.

	ALTERNATIVE 1 - NO ACTION Option 1 Wet Storage
Land Use	No new facilities would be required.
Socioeconomics	No new operations jobs and only about 50 construction jobs would be created.
Cultural Resources	No new construction would be carried out. No impacts are anticipated.
Aesthetics and Scenic Resources	Facilities are in an existing industrial area not visible from public access roads or from off the Site. No impacts are anticipated. Emissions would not impact visibility.
Geology	No minerals of economic value are in affected area. No impacts are anticipated.
Air Resources	Emissions of criteria air pollutants and toxic air pollutants would be only a small fraction of air quality standards.
Water Resources	This option would not require use of additional surface water beyond the 75.7 billion liters (20 billion gallons) per year that the SRS withdraws at present. This option would not require withdrawals of additional groundwater beyond the 14.0 billion liters (3.7 billion gallons) per year the SRS uses. Activities related to this option currently use about 35.1 million liters (9.3 million gallons) of groundwater per year. Impacts would be minimal. No perennial streams or other surface waters would be affected. Accidental releases could contaminate shallow groundwater that is not a source for drinking water or domestic use. Releases would not affect surface streams or drinking water aquifers.
Ecological Resources	Minor disturbance of wildlife due to traffic would occur. No wetlands or threatened or endangered species would be affected.
Noise	The only noise experienced by offsite populations would

	be generated by employee traffic and by truck and rail deliveries. There would be no change in traffic noise impacts.
Traffic and Transportation	This option would not increase site traffic. Number of LCFf, normal transport: Worker: 6.0 x 10-4 Public: 7.0 x 10-5
Occupational and Public Health and Safety (Radiological)	Maximum LCFf probabilities: Worker: 4 x 10-5 Offsite population: 4 x 10-14 (air) 1 x 10-14 (water) Annual LCFf incidences: Worker: 8 x 10-5 Offsite population: 2 x 10-9

Table 3-3. (continued).

	Option 1 Wet Storage
Occupational and Public Health and Safety (Nonradiological)	Hazard index: Worker: 2 x 10-6 Maximally exposed individual: 2 x 10-7
Utilities and Energy	Minimal changes in demand for electricity, steam, domestic water and wastewater treatment would occur. Current SRS capacities are adequate for these additions. Impacts would be minimal.
Materials and Waste Management	Annual average volume of waste generated (cubic meters)b: LLW: 400 TRU: 17 HLW: 0.4 No impact on site waste management capacities.
Accidentsc	Greatest point estimate of riskd: Worker: Data not calculatede Colocated worker: 7.7 x 10-7 Maximally exposed individual: 1.6 x 10-7 Offsite population: 1.4 x 10-3

a. Not applicable.

b. LLW = low-level waste; TRU = transuranic waste; HLW = high-level waste.

c. Data is provided as adjusted point estimates of risk by receptor group to demonstrate a relative comparison of each alternative on an option-by-option basis. The adjusted values were taken from Tables 5-27 through 5-29.

d. Units for adjusted point estimates of risk are given in terms of potential fatal cancers per year.

e. The safety analysis reports from which information was extracted were written before issuance of DOE Order 5480.23; previous orders did not require the inclusion of workers.

f. LCF = latent cancer fatalities.

Table 3-3. (continued).

	ALTERNATIVE 2 - DECENTRALIZATION		
	Option 2a Dry Storage	Option 2b Wet Storage	Option 2c Processing
Land Use	Most new construction would be in parts of F- and H-Areas already dedicated to industrial use. Impacts would be minimal.	Same as Option 2a.	Same as Option 2a.
Socioeconomics	Operations jobs would be filled by current employees. A maximum of about 600 construction jobs would be created.	Same as Option 2a.	Operations jobs would be filled by current employees. A maximum of about 550 construction jobs would be created.
Cultural Resources	Same as Option 1.	Same as Option 1.	Same as Option 1.
Aesthetics and Scenic Resources	Same as Option 1.	Same as Option 1.	Same as Option 1.
Geology	Same as Option 1.	Same as Option 1.	Same as Option 1.

Air Resources	Same as Option 1.	Same as Option 1.	Same as Option 1.
Water Resources	New withdrawals of approximately 6.1 million liters (1.6 million gallons) per year of cooling water from Savannah River would be required. Impacts would be minimal.	New withdrawals of approximately 7.2 million liters (1.9 million gallons) per year of cooling water from Savannah River would be required. Impacts would be minimal.	New withdrawals of approximately 311 million liters (82.2 million gallons) per year of cooling water from Savannah River would be required. Impacts would be minimal.
	Additional groundwater withdrawals would total about 48.7 million liters (12.9 million gallons) per year. Impacts would be minimal.	Additional groundwater withdrawals would total about 50.6 million liters (13.4 million gallons) per year. Impacts would be minimal.	Same as Option 2a.
	No perennial streams or other surface waters would be affected.	No perennial streams or other surface waters would be affected.	No perennial streams or other surface waters would be affected.
	Accidental releases could contaminate shallow groundwater that is not used as a source for drinking water or domestic use. Releases would not affect surface streams or drinking water aquifers.	Accidental releases could contaminate shallow groundwater that is not used as a source for drinking water or domestic use. Releases would not affect surface streams or drinking water aquifers.	Accidental releases could contaminate shallow groundwater that is not used as a source for drinking water or domestic use. Releases would not affect surface streams or drinking water aquifers.

Table 3-3. (continued).

	Option 2a Dry Storage	Option 2b Wet Storage	Option 2c Processing
Ecological Resources	Small increase in traffic would cause slight increase in road kills and in disturbance of wildlife due to noise. Impacts would be minimal.	Same as Option 2a.	Small increases in traffic would cause small increase in road kills and in disturbance of wildlife due to noise. Impacts would be minimal.
	No wetlands or threatened or endangered species would be affected.	Same as Option 2a.	Same as Option 2a.
Noise	Only noise experienced by communities would be generated by employee traffic and by truck and rail deliveries.	Same as Option 2a.	Same as Option 2a.
	Changes in traffic levels are expected to result in only very small changes in noise impacts.		
Traffic and Transportation	This option would increase site traffic slightly.	Same as Option 2a.	This option would increase site traffic slightly.
	Number of LCFg, normal transport: Worker: 1.0 x 10-3 Public: 1.2 x 10-4		Number of LCFg, normal transport: Worker: 2.1 x 10-4 Public: 1.9 x 10-5
Occupational and Public Health and Safety (Radiologica	Maximum LCFg probabilities: Worker: 3 x 10-5 Offsite population: 4 x 10-14 (air)	Maximum LCFg probabilities: Worker: 4 x 10-5 Offsite population:	Maximum LCFg probabilities: Worker: 6 x 10-5 Offsite population:

l)	1 x 10-14 (water) Annual LCF[g] incidences: Worker: 7 x 10-5 Offsite population: 2 x 10-9	5 x 10-14 (air) 2 x 10-14 (water) Annual LCF[g] incidences: Worker: 8 x 10-5 Offsite population: 2 x 10-9	2 x 10-7 (air) 6 x 10-8 (water) Annual LCF[g] incidences: Worker: 3 x 10-2 Offsite population: 8 x 10-3
Occupational and Public Health and Safety (Nonradiological)	Same as Option 1.	Same as Option 1.	Hazard index: Worker: 6 x 10-3 Maximally exposed individual: 5 x 10-4
Utilities and Energy	Requirements would increase 3 to 7 percent above present levels. Current SRS capacities are adequate for these increases.	Same as Option 2a.	Very similar to Option 2a.
Materials and Waste Management	Annual average volume of waste generated (cubic meters)[b]: LLW: 400 TRU: 18 HLW: 0.4 No impact on site capacities.	Same as Option 2a.	Annual average volume of waste generated (cubic meters)[b]: LLW: 800 TRU: 19 HLW: 2.3[c] No impact on site capacities.

Table 3-3. (continued).

	Option 2a Dry Storage	Option 2b Wet Storage	Option 2c Processing
Accidents[d]	Greatest point estimate of risk[e]: Worker: Data not calculated[f] Colocated worker: 1.6 x 10-6 Maximally exposed individual: 3.3 x 10-7 Offsite population: 2.8 x 10-3	Greatest point estimate of risk[e]: Worker: Data not calculated[f] Colocated worker: 1.7 x 10-6 Maximally exposed individual: 3.5 x 10-7 Offsite population: 3.0 x 10-3	Greatest point estimate of risk[e]: Worker: Data not calculated[f] Colocated worker: 7.7 x 10-7 Maximally exposed individual: 1.6 x 10-7 Offsite population: 1.4 x 10-3

a. NA = not applicable.
b. LLW = low-level waste; TRU = transuranic waste; HLW = high-level waste.
c. High-level waste will be generated only during approximately the first 10 years.
d. Data is provided as adjusted point estimates of risk by receptor group to demonstrate a relative comparison of each alternative on an option-by-option basis. The adjusted values were taken from Tables 5-27 through 5-29.
e. Units for adjusted point estimates of risk are given in terms of potential fatal cancers per year.
f. The safety analysis reports from which information was extracted were written before issuance of DOE Order 5480.23; previous orders did not require the inclusion of workers.
g. LCF = latent cancer fatalities.

Table 3-3. (continued).

ALTERNATIVE 3 - 1992/1993 PLANNING BASIS

	Option 3a Dry Storage	Option 3b Wet Storage	Option 3c Processing
Land Use	Same as Option 2a.	Same as Option 2a.	Same as Option 2a.
Socioeconomics	Same as Option 2a.	Operations jobs would be filled by current employees. A maximum of about 650 construction jobs would be created.	Same as Option 2c.
Cultural Resources	Same as Option 1.	Same as Option 1.	Same as Option 1.
Aesthetics and Scenic Resources	Same as Option 1.	Same as Option 1.	Same as Option 1.

Geology	Same as Option 1.	Same as Option 1.	Same as Option 1.
Air Resources	Same as Option 1.	Same as Option 1.	Same as Option 1.
Water Resources	Same as Option 2a.	Same as Option 2b.	Same as Option 2c.
Ecological Resources	Same as Option 2a.	Same as Option 2a.	Same as Option 2c.
Noise	Same as Option 2a.	Same as Option 2a.	Same as Option 2a.
Traffic and Transportation	Same as Option 2a.	Same as Option 2a.	Same as Option 2c.
Occupational and Public Health and Safety (Radiological)	Same as Option 2a.	Same as Option 2b.	Same as Option 2c.
Occupational and Public Health and Safety (Nonradiological)	Same as Option 1.	Same as Option 1.	Same as Option 2c.
Utilities and Energy	Same as Option 2a.	Same as Option 2a.	Very similar to Option 2a.
Materials and Waste Management	Same as Option 2a.	Same as Option 2a.	Annual average volume of waste generated (cubic meters)a: LLW: 750 TRU: 19 HLW: 1.7b No impact on site capacities.
Accidentsc	Greatest point estimate of riskd: Worker: Data not calculatede Colocated worker: 1.9 x 10-6 Maximally exposed individual: 4.0 x 10-7 Offsite population: 3.4 x 10-3	Same as Option 3a.	Greatest point estimate of riskd: Worker: Data not calculatede Colocated worker: 1.1 x 10-6 Maximally exposed individual: 2.3 x 10-7 Offsite population: 2.0 x 10-3

a. LLW = low-level waste; TRU = transuranic waste; HLW = high-level waste.

b. High-level waste will be generated only during approximately the first 10 years.

c. Data is provided as adjusted point estimates of risk by receptor group to demonstrate a relative comparison of each alternative on an option-by-option basis. The adjusted values were taken from Tables 5-27 through 5-29.

d. Units for adjusted point estimates of risk are given in terms of potential fatal cancers per year.

e. The safety analysis reports from which information was extracted were written before issuance of DOE Order 5480.23; previous orders did not require the inclusion of workers.

Table 3-3. (continued).

	ALTERNATIVE 4 - REGIONALIZATION A (By Fuel Type)		
	Option 4a Dry Storage	Option 4b Wet Storage	Option 4c Processing
Land Use	Same as Option 2a.	Same as Option 2a.	Same as Option 2a.
Socioeconomics	Same as Option 3b.	Same as Option 3b.	Same as Option 2c.
Cultural Resources	Same as Option 1.	Same as Option 1.	Same as Option 1.
Aesthetics and Scenic Resources	Same as Option 1.	Same as Option 1.	Same as Option 1.
Geology	Same as Option 1.	Same as Option 1.	Same as Option 1.
Air Resources	Same as Option 1.	Same as Option 1.	Same as Option 1.
Water Resources	Same as Option 2a.	Same as Option 2b.	Very similar to Option 2c.
Ecological Resources	Same as Option 2a.	Same as Option 2a.	Same as Option 2c.

Noise	Same as Option 2a.	Same as Option 2a.	Same as Option 2a.
Traffic and Transportation	Same as Option 2a.	Same as Option 2a.	Same as Option 2c.
Occupational and Public Health and Safety (Radiological)	Same as Option 2a.	Same as Option 2b.	Maximum LCF[a] probabilities: Same as Option 2c. Annual LCF[a] incidences: Worker: 3 x 10-2 Offsite population: 9 x 10-3
Occupational and Public Health and Safety (Nonradiological)	Same as Option 1.	Same as Option 1.	Same as Option 2c.
Utilities and Energy	Very similar to Option 2a.	Same as Option 2a.	Very similar to Option 2a.
Materials and Waste Management	Same as Option 1.	Same as Option 1.	Annual average volume of waste generated (cubic meters)[b]: LLW: 790 TRU: 18 HLW: 2.3[c] No impact on site capacities.

Table 3-3. (continued).

	Option 4a Dry Storage	Option 4b Wet Storage	Option 4c Processing
Accidents[d]	Greatest point estimate of risk[e]: Worker: Data not calculated[f] Colocated worker: 2.1 x 10-6 Maximally exposed individual: 4.4 x 10-7 Offsite population: 3.7 x 10-3	Same as Option 3a.	Greatest point estimate of risk[e]: Worker: Data not calculated[f] Colocated worker: 1.3 x 10-6 Maximally exposed individual: 2.8 x 10-7 Offsite population: 2.4 x 10-3

a. LCF = latent cancer fatalities.

b. LLW = low-level waste; TRU = transuranic waste; HLW = high-level waste.

c. High-level waste will be generated only during approximately the first 10 years.

d. Data is provided as adjusted point estimates of risk by receptor group to demonstrate a relative comparison of each alternative on an option-by-option basis. The adjusted values were taken from Tables 5-27 through 5-29.

e. Units for adjusted point estimates of risk are given in terms of potential fatal cancers per year.

f. The safety analysis reports from which information was extracted were written before issuance of DOE Order 5480.23; previous orders did not require the inclusion of workers.

Table 3-3. (continued).

ALTERNATIVE 4 - REGIONALIZATION B (By Location)[a]

	Option 4d Dry Storage	Option 4e Wet Storage	Option 4f Processing
Land Use	Same as Option 2a.	Same as Option 2a.	Same as Option 2a.
Socioeconomics	Operations jobs would be filled by current employees. A maximum of about 700 construction jobs would be created.	Operations jobs would be filled by current employees. A maximum of about 800 construction jobs would be created.	Same as Option 3b.
Cultural Resources	Same as Option 1.	Same as Option 1.	Same as Option 1.
Aesthetics and Scenic Resources	Same as Option 1.	Same as Option 1.	Same as Option 1.
Geology	Same as Option 1.	Same as Option 1.	Same as Option 1.

Air Resources	Same as Option 1.	Same as Option 1.	Same as Option 1.
Water Resources	Same as Option 2a.	Same as Option 2b.	Very similar to Option 2c.
Ecological Resources	Same as Option 2a.	Same as Option 2a.	Same as Option 2c.
Traffic and Transportation	Same as Option 2a.	Same as Option 2a.	Same as Option 2c.
Occupational and Public Health and Safety (Radiological)	Maximum LCFe probabilities: Worker: 4 x 10-5 Offsite population: 5 x 10-14 (air) 2 x 10-14 (water) Annual LCFe incidences: Worker: 8 x 10-5 Offsite population: 2 x 10-9	Maximum LCFe probabilities: Worker: 5 x 10-5 Offsite population: 6 x 10-14 (air) 2 x 10-14 (water) Annual LCFe incidences: Worker: 1 x 10-4 Offsite population: 2 x 10-9	Maximum LCFe probabilities: Worker: 7 x 10-5 Offsite population: 2 x 10-7 (air) 6 x 10-8 (water) Annual LCFe incidences: Worker: 3 x 10-2 Offsite population: 9 x 10-3
Occupational and Public Health and Safety (Nonradiological)	Hazard index: Worker: 2 x 10-6 Maximally exposed individual: 3 x 10-7	Same as Option 4d.	Hazard index: Worker: 8 x 10-3 Maximally exposed individual: 6 x 10-4
Utilities and Energy	Same as Option 2a.	Very similar to Option 2a.	Very similar to Option 2a.
Materials and Waste Management	Same as Option 1.	Same as Option 1.	Same as Option 4c.

Table 3-3. (continued).

	Option 4d Dry Storage	Option 4e Wet Storage	Option 4f Processing
Accidentsb	Greatest point estimate of riskc: Worker: Data not calculatedd Colocated worker: 2.0 x 10-6 Maximally exposed individual: 4.1 x 10-7 Offsite population: 3.5 x 10-3	Same as Option 4d	Greatest point estimate of riskc: Worker: Data not calculatedd Colocated worker: 1.2 x 10-6 Maximally exposed individual: 2.5 x 10-7 Offsite population: 2.1 x 10-3

a. Impacts for Option 4g, Ship Offsite, would be the same as for Option 5d as described in the last entry in this table.

b. Data is provided as adjusted point estimates of risk by receptor group to demonstrate a relative comparison of each alternative on an option-by-option basis. The adjusted values were taken from Tables 5-27 through 5-29.

c. Units for adjusted point estimates of risk are given in terms of potential fatal cancers per year.

d. The safety analysis reports from which information was extracted were written before issuance of DOE Order 5480.23; previous orders did not require the inclusion of workers.

e. LCF = latent cancer fatalities.

Table 3-3. (continued).

ALTERNATIVE 5 - CENTRALIZATION

	Option 5a Dry Storage	Option 5b Wet Storage	Option 5c Processing
Land Use	Most new construction would be in parts of F- and H-Areas already dedicated to industrial use. Additional maximum of 0.4 square kilometer (100 acres) would be converted from pine plantation to industrial use. Impacts would be minimal.	Same as Option 5a.	Same as Option 5a.

Socioeconomics	Operations jobs would be filled by present employees. A maximum of about 2,550 construction jobs would be created.	Operations jobs would be filled by present employees. A maximum of about 2,700 construction jobs would be created.	Operations jobs would be filled by present employees. A maximum of about 2,550 construction jobs would be created.
Cultural Resources	No known historical, archeological, or paleontological resources are in areas to be affected. All areas are classified as having low or moderate probability of containing archeological site. Impact is unlikely.	Same as Option 5a.	Same as Option 5a.
Aesthetics and Scenic Resources	Same as Option 1.	Same as Option 1.	Same as Option 1.
Geology	Same as Option 1.	Same as Option 1.	Same as Option 1.
Air Resources	Same as Option 1.	Same as Option 1.	Same as Option 1.
Water Resources	Same as Option 2a.	Same as Option 2b.	Same as Option 2c.
	Additional groundwater withdrawals would total about 67.7 million liters (17.9 million gallons) per year. Impacts would be minimal.	Additional groundwater withdrawals would total about 69.6 million liters (18.4 million gallons) per year. Impacts would be minimal.	Same as Option 5a.
	No perennial streams or other surface waters would be affected.	Same as Option 5a.	Same as Option 5a.
	Accidental releases could contaminate shallow groundwater that is not used as a source for drinking water or domestic use. Releases would not affect surface streams or drinking water aquifers.	Accidental releases could contaminate shallow groundwater that is not used as a source for drinking water or domestic use. Releases would not affect surface streams or drinking water aquifers.	Accidental releases could contaminate shallow groundwater that is not used as a source for drinking water or domestic use. Releases would not affect surface streams or drinking water aquifers.

Table 3-3. (continued).

	Option 5a Dry Storage	Option 5b Wet Storage	Option 5c Processing
Ecological Resources	Same as Option 2a, plus Loss of up to 0.4 square kilometer (100 acres) of loblolly pine. Impacts would be minor.	Same as Option 5a.	Same as Option 5a, plus Increased disturbance due to more worker traffic. Impacts would be minor.
Noise	Same as Option 2a.	Same as Option 2a.	Same as Option 2a.
Traffic and Transportation	Same as Option 2a.	This option would increase site traffic by about 17 percent. Impacts would be small. Number of LCFsg would be same as for Option 2b for normal transport.	Same as Option 2c.
Occupational and Public Health and Safety (Radiologica	Maximum LCFg probabilities: Worker: 4 x 10-4 Offsite population:	Maximum LCFg probabilities: Worker: 5 x 10-4 Offsite population:	Maximum LCFg probabilities: Worker: 6 x 10-4 Offsite population:

l)	5 x 10-13 (air) 2 x 10-13 (water) Annual LCFg incidences: Worker: 9 x 10-4 Offsite population: 2 x 10-8	6 x 10-13 (air) 2 x 10-13 (water) Annual LCFg incidences: Worker: 1 x 10-3 Offsite population: 3 x 10-8	2 x 10-7 (air) 6 x 10-8 (water) Annual LCFg incidences: Worker: 3 x 10-2 Offsite population: 9 x 10-3
Occupational and Public Health and Safety (Nonradiological)	Same as Option 1.	Same as Option 1.	Same as Option 2c.
Utilities and Energy	Similar to Option 2a.	Similar to Option 2a.	Requirements for electricity would increase by about 17 percent. Other increases would be similar to Option 2c. Impacts would be minor.
Materials and Waste Management	Annual average volume of waste generated (cubic meters)b: LLW: 400 TRU: 16 HLW: 0 No impact on site capacities.	Annual average volume of waste generated (cubic meters)b: LLW: 400 TRU: 20 HLW: 2.3c No impact on site capacities.	Annual average volume of waste generated (cubic meters)b: LLW: 800 TRU: 20 HLW: 2.3c No impact on site capacities.

Table 3-3. (continued).

	Option 5a Dry Storage	Option 5b Wet Storage	Option 5c Processing
Accidentsd	Greatest point estimate of riske: Worker: Data not calculatedf Colocated worker: 4.0 x 10-6 Maximally exposed individual: 8.4 x 10-7 Offsite population: 7.2 x 10-3	Same as Option 5a.	Greatest point estimate of riske: Worker: Data not calculatedf Colocated worker: 3.3 x 10-6 Maximally exposed individual: 6.8 x 10-7 Offsite population: 5.8 x 10-3

a. NA = not applicable.
b. LLW = low-level waste; TRU = transuranic waste; HLW = high-level waste.
c. High-level waste will be generated only during approximately the first 10 years.
d. Data is provided as adjusted point estimates of risk by receptor group to demonstrate a relative comparison of each alternative on an option-by-option basis. The adjusted values were taken from Tables 5-27 through 5-29.
e. Units for adjusted point estimates of risk are given in terms of potential fatal cancers per year.
f. The safety analysis reports from which information was extracted were written before issuance of DOE Order 5480.23; previous orders did not require the inclusion of workers.
g. LCF = latent cancer fatalities.

Table 3-3. (continued).

	ALTERNATIVE 5 - CENTRALIZATION ALTERNATIVE 4 - REGIONALIZATION B Option 4g and Option 5db Ship Out
Land Use	Same as Option 1.
Socioeconomics	No new operations jobs and only about 200 construction jobs would be created.
Cultural Resources	Same as Option 1.
Aesthetics and Scenic Resources	Same as Option 1.
Geology	Same as Option 1.
Air Resources	Same as Option 1.
Water Resources	This option would require new withdrawals of approximately 3.0 million liters (790 thousand gallons) per year of cooling water from the Savannah River. Impacts would be minimal.

	It also would require additional groundwater withdrawals of about 38.1 million liters (10.1 million gallons) per year. Impacts would be minimal. Impacts to surface water and groundwater would be similar to those from Option 1.
Ecological Resources	Same as Option 1.
Noise	Same as Option 2a.
Traffic and Transportation	NA[a]
Occupational and Public Health and Safety (Radiological)	Less than Option 1.
Occupational and Public Health and Safety (Nonradiological)	Same as Option 1.
Utilities and Energy	Requirements would increase 2 to 6 percent above current levels during first 10 years. Current SRS capacities are adequate for these increases.
Materials and Waste Management	Annual average volume of waste generated initial 10 years only (cubic meters)[c]: LLW: 400 TRU: 18 HLW: 0

Table 3-3. (continued).

	Option 4g and Option 5d[b] Ship Out
Accidents[d]	Greatest point estimate of risk[e]: Worker: Data not calculated[f] Colocated Worker: Option 4g: 8.1×10^{-7} Option 5d: 8.2×10^{-7} Maximally exposed individual: Option 4g: 1.7×10^{-7} Option 5d: 1.7×10^{-7} Offsite population: Option 4g: 1.4×10^{-3} Option 5d: 1.4×10^{-3}

a. NA = not applicable.
b. Impacts for Option 4g (Regionalization-B) are the same as for Option 5d.
c. LLW = low-level waste; TRU = transuranic waste; HLW = high-level waste.
d. Data is provided as adjusted point estimates of risk by receptor group to demonstrate a relative comparison of each alternative on an option-by-option basis. The adjusted values were taken from Tables 5-27 through 5-29.
e. Units for adjusted point estimates of risk are given in terms of potential fatal cancers per year.
f. The safety analysis reports from which information was extracted were written before issuance of DOE Order 5480.23; previous orders did not require the inclusion of workers.

4. AFFECTED ENVIRONMENT

4.1 Overview

This section describes the existing environment at the Savannah River Site (SRS) and nearby areas. Its purpose is to support the assessment of environmental consequences of the alternative actions regarding spent nuclear fuels described in Chapter 3. Chapter 5 describes the environmental consequences in detail.

4.2 Land Use

The SRS occupies an area of approximately 198,000 acres (800 square kilometers) in western South Carolina, in a generally rural area about 25 miles (40 kilometers) southeast of Augusta, Georgia. The SRS, which is bordered by the Savannah River to the southwest, includes portions of Aiken, Barnwell, and Allendale Counties (Figure 2-1).

Land use on the SRS falls into three major categories: forest/undeveloped, water/wetlands, and developed facilities. About 181,500 acres (735 square kilometers) of the SRS area are undeveloped (USDA 1991a). Approximately 90 percent of this undeveloped area is forested (Cummins et al. 1991). In 1952, an interagency agreement between the U.S. Department of Energy [DOE, which was then the Atomic Energy Commission (AEC)] and the Forest Service, U.S. Department of Agriculture, created an SRS forest management program. In 1972, the AEC designated the SRS as a National Environmental Research Park (NERP); at present, approximately 14,000 acres (57 square kilometers or 7 percent) of the SRS area are designated as "Set-Asides," areas specifically protected for environmental research activities that are coordinated either through the University of Georgia Savannah River Ecology Laboratory (SREL) or the Savannah River Technology Center (SRTC; Davis 1994). Administrative, production, and support facilities occupy approximately 5 percent of the total SRS land area.

DOE is considering decisions that could affect the long-range land use of the SRS. Programmatic decisions on the reconfiguration of the nuclear weapons complex, spent nuclear fuel interim strategies, and waste management and environmental restoration activities that could result in significant changes in the SRS mission are in the early stages of discussion. In the shorter term, however, a Land Use Technical Committee consisting of representatives from DOE, Westinghouse Savannah River Company, and various stakeholder groups is evaluating alternative land use strategies and potential future uses. These activities are consistent with the guidelines for land use plans contained in DOE Order 4320.1B, "Site Development Planning," and in the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

Land use bordering SRS is primarily forest and agricultural. There is also a significant amount of open water and nonforested wetlands along the Savannah River valley. Incorporated and industrial areas are the only other significant use of land in the vicinity (Figure 4-1). None of the three counties in which the SRS is located has zoned any of the Site land. The only adjacent area with any zoning is the Town of New Ellenton, which has two zoning categories for lands that bound SRS - urban development and residential development. The closest residences to the SRS boundary include several within 200 feet (61 meters) of the Site perimeter to the west, north, and northeast.

Various industrial, manufacturing, medical, and farming operations are conducted in areas surrounding the Site. Major industrial and manufacturing facilities in the area include textile mills, plants producing polystyrene foam and paper products, chemical processing plants, and a commercial nuclear power plant. Farming is diversified in the region and includes crops such as peaches, watermelon, cotton, soybeans, corn, and small grains.

There is a wide variety of public outdoor recreation facilities in the SRS region (Figure 4-2). Federal outdoor recreation facilities include portions of the Sumter National Forest [47 miles (75 kilometers) to the northwest of the Site], the Santee National Wildlife Refuge [50 miles (80 kilometers) to the east], and the Clarks Hill/Strom Thurmond Reservoir, a U.S. Army Corps of Engineers impoundment [43 miles (70 kilometers) to the northwest]. There are also a number of state, county, and local parks in the region, most notably Redcliffe Plantation, Rivers Bridge, Barnwell and Aiken County State Parks in South Carolina, and Mistletoe State Park in Georgia (HNUS 1992a).

The SRS is a controlled area with public access limited to through traffic on South Carolina Highway 125 (SRS Road A), U.S. Highway 278, SRS Road 1, and the CSX railway. The SRS does not contain any public recreation facilities. However, the SRS conducts controlled deer hunts each fall, from mid-October through mid-December; hunters can also kill feral hogs during these hunts. The intent of the hunts is to control the resident populations of these animals and to reduce animal-vehicle accidents on SRS roads.

Figure 4-1. Generalized land use at the Savannah River Site and vicinity. Figure 4-2. Federal and state forests and parks within a 2-hour drive from Savannah River Site.

No onsite areas are subject to Native American treaty rights. The SRS does not contain any prime farmland.

4.3 Socioeconomics

This section discusses baseline socioeconomic conditions within a region of influence where approximately 90 percent of the SRS workforce lived in 1992. The SRS region of influence includes Aiken, Allendale, Bamberg, and Barnwell Counties in South Carolina, and Columbia and Richmond Counties in Georgia (Figure 4-2).

4.3.1 Employment and Labor Force

The labor force living in the region of influence increased from about 150,550 to 209,000 between 1980 and 1990. In 1990, approximately 75 percent of the total labor force in the region of influence lived in Richmond and Aiken Counties. Assuming a constant unemployment rate of 5.8 percent, the regional labor force is likely to increase to approximately 257,000 by 1995 (Table 4-1).

Between 1980 and 1990, total employment in the region of influence increased from 139,504 to 199,161, an average annual growth rate of approximately 5 percent. Table 4-1 lists projected employment data for the six-county region of influence. As shown, by 1995 employment levels should increase 22 percent to approximately 242,000. The unemployment rates for 1980 and 1990 were 7.3 percent and 4.7 percent, respectively (HNUS 1992a).

In 1990, employment at the SRS was 20,230 (DOE 1993a), representing 10 percent of the employment in the region of influence. In Fiscal Year 1992, employment at the SRS increased approximately 15 percent to 23,351, with an associated payroll of more than $1.1 billion. Due to planned budget reductions, Site employment could decline by as many as 4,200 jobs (Fiori 1995). As shown in Table 4-1, this would reduce Site employment to approximately 15,800 by 1996.

Table 4-1. Forecast employment and population data for the Savannah River Site and the region of influence.

Year	Labor Force (Region)	Employment (Region)	SRS Employmentb	Population (Region)
1994	254,549	239,785	21,500	456,892
1995	256,935	242,033	20,000	461,705
1996	258,500	243,507	15,800	465,563
1997	260,680	245,561	15,800	468,665
1998	263,121	247,860	15,800	471,176
1999	265,694	250,284	15,800	473,186
2000	268,430	252,861	15,800	474,820
2001	271,265	255,532	15,800	476,179
2002	274,238	258,332	15,800	477,332
2003	277,318	261,234	15,800	478,340
2004	280,415	264,151	15,800	479,182

a. Source: HNUS (1993).
b. Sources: Turner (1994), Fiori (1995).

4.3.2 Personal Income

Personal income in the six-county region has doubled during the past two decades, increasing from approximately $3.4 billion in 1970 to almost $6.9 billion by 1989 (in constant 1991 dollars). Together, Richmond and Aiken Counties accounted for 75.4 percent of the personal income in the region of influence in 1989, because these two counties provide most of the employment opportunities in the region. Personal income in the region is likely to increase 3 percent to approximately $7.1 billion by 1995 and to almost $8.2 billion by 2000 (HNUS 1992a).

4.3.3 Population

Between 1980 and 1990, the population in the region of influence increased 13 percent from 376,058 to 425,607. More than 88 percent of the 1990 population lived in Aiken (28.4 percent), Columbia (15.5 percent), and Richmond (44.6 percent) Counties. Table 4-1 also lists population data for the region of influence forecast to 2004. According to census data, in 1990 the estimated average number of persons per household in the six-county region was 2.72, and the median age of the population was 31.2 years (HNUS 1992a).

4.3.4 Housing

From 1980 to 1990, the number of year-round housing units in the six-county region increased 23.2 percent from 135,866 to 167,356. In 1990, approximately 68 percent of the total housing units were single-family units, 18 percent were multifamily units, and 14 percent were mobile homes. In the same year, the region had a 4.7-percent vacancy rate with 7,818 available unoccupied housing units. Of the available unoccupied units, 29 percent (2,267) were available for sale and 71 percent (5,551) were available for rent (HNUS 1992a).

4.3.5 Community Infrastructure and Services

Public education facilities in the six-county region include 95 elementary and intermediate schools and 25 high schools. Aside from the public school systems, 42 private schools and 16 post-secondary facilities are available to residents in the region (HNUS 1992a).

Based on a combined average daily attendance for elementary and high school students in the region of influence in 1988, the average number of students per teacher was 16. The highest ratio was in Columbia County high schools where there were 19 students per teacher (1987-1988). The lowest ratio occurred in Barnwell County's District 29 high school, which had only 12 students per teacher (1988-1989) (HNUS 1992a).

The six-county region has 14 major public sewage treatment facilities with a combined design capacity of 302.2 million liters (79.8 million gallons) per day. In 1989, these systems were operating at approximately 56 percent of capacity, with an average daily flow of 170 million liters (44.9 million gallons) per day. Capacity utilization ranged from 45 percent in Aiken County to 80 percent in Barnwell County (HNUS 1992a).

There are approximately 120 public water systems in the region of influence. About 40 of these county and municipal systems are major facilities, while the remainder serve individual subdivisions, water districts, trailer parks, and miscellaneous facilities. In 1989, the 40 major facilities had a combined total capacity of 576.3 million liters (152.2 million gallons) per day. With an average daily flow rate of approximately 268.8 million liters (71 million gallons) per day, these systems were operating at 47 percent of total capacity in 1989. Facility utilization rates ranged from 13 percent in Allendale County to 84 percent in the City of Aiken (HNUS 1992a).

Eight general hospitals operate in the six-county region with a combined bed capacity in 1987 of 2,433 (5.7 beds per 1,000 population). Four of the eight general hospitals are in Richmond County; Aiken, Allendale, Bamberg, and Barnwell Counties each have one general hospital. Columbia County has no hospital. In 1989, there were approximately 1,295 physicians serving the regional population, which represents a physician-to-population ratio of 3 to 1,000. This ratio ranged from 0.8 physician per 1,000 people in Aiken and Allendale Counties to 5.4 physicians per 1,000 people in Richmond County (HNUS 1992a).

Fifty-six fire departments provide fire protection services in the region of influence. Twenty-seven of these are classified as municipal fire departments, but many provide protection to rural areas outside municipal limits. The average number of firefighters in the region in 1988 was 3.8 per 1,000 people, ranging from 1.6 per 1,000 in Richmond County to 10.2 per 1,000 in Barnwell County (HNUS 1992a).

The county sheriff departments and municipal police departments provide most law enforcement services in the region of influence. In addition, state law enforcement agents and state troopers assigned to each county provide protection and assist county and municipal law enforcement officers. In 1988, the average ratio in the region of full-time police officers employed by state, county, and local agencies per 1,000 population was 2.0. This ratio ranged from 1.4 per 1,000 in Columbia County to 2.5 per 1,000 in Richmond County (HNUS 1992a).

4.3.6 Government Fiscal Structure

This section discusses the fiscal structure of Aiken and Barnwell Counties because these two counties would have the greatest potential for fiscal impacts from changes at SRS.

Public services provided by Aiken County are funded principally through the county's general fund. In Fiscal Year 1988, revenues and expenditures of this fund were $15.5 million and $18 million, respectively. The current property tax rate is 55.8 mills for county operations and 8.0 mills for debt service. Long-term general obligation bond indebtedness was $9.3 million at the end of Fiscal Year 1988, and reserve general obligation bond indebtedness was $5.5 million. The assessed value of property in the county was $182.5 million in Fiscal Year 1988 (HNUS 1992a).

Assuming revenues and expenditures increase in proportion to projected growth in the employment and population, estimated revenues and expenditures for Aiken County over the period from Fiscal Year 1990 to Fiscal Year 2000 will be $15.6 million to $17.0 million (in constant 1988 dollars) (HNUS 1992a).

Public services provided by Barnwell County also are funded principally through the county's general fund. In Fiscal Year 1988, revenues and expenditures of this fund were $4.0 million and $4.9 million, respectively. The property tax rate is 23.9 mills of assessed valuation. Budgeted Fiscal Year 1990 revenues were approximately $4.5 million (HNUS 1992a).

4.4 Cultural Resources

4.4.1 Archeological Sites and Historic Structures

Field studies conducted under an ongoing program over the past two decades by the South Carolina Institute of Archeology of the University of South Carolina, under contract to DOE and in consultation with the South Carolina State Historic Preservation Officer, have provided considerable information about the distribution and content of archeological and historic resources on the SRS. By the end of Fiscal Year 1992, approximately 60 percent of the Site had been examined, and 858 archeological (historic and prehistoric) sites had been identified; these include 706 prehistoric and 350 historic components, some of which are mixed (i.e., contain elements of both). Of the 858 sites, 53 have been determined to be eligible for the National Register of Historic Places; 650 have not been evaluated. Approximately 21 of the 53 (40 percent) are historic sites, such as building foundations; none are standing structures. These sites provide knowledge of the area's history before 1820. The remainder are primarily prehistoric sites and some are mixed (historic and prehistoric). No SRS facilities have been nominated for eligibility to the National Register for Historic Places and there are no plans for such a nomination at this time (Brooks 1993; Brooks 1994). The existing SRS nuclear production facilities are not likely to be eligible for the National Register, either because they might lack architectural integrity, might not represent a particular architectural style, or might not contribute to the broad historic theme of the Manhattan Project and initial nuclear materials production (DOE 1993a).

Archeologists have divided areas of the SRS into three sensitivity zones related to their potential for containing sites with multiple archeological components or dense or diverse artifacts, and their potential for eligibility to the National Register of Historic Places (SRARP 1989).

- Zone 1 is the zone of the highest archeological site density with a high probability of encountering large archeological sites with dense and diverse artifacts, and high potential for nomination to the National Register of Historic Places.
- Zone 2 covers areas of moderate archeological site density that should contain sites of similar composition. Activities in this zone have a moderate probability of encountering archeological sites, but a low probability of encountering large sites with more than three prehistoric components. All areas within the zone are conducive to site preservation. The zone has moderate potential for encountering sites that would be eligible for nomination to the National Register of Historic Places.
- Zone 3 covers areas of low archeological site density. Activities in this zone have a low probability of encountering archeological sites and virtually no chance of encountering large sites with more than three prehistoric components; potential for site preservation is low. Some exceptions to this definition have been discovered in Zone 3, so some sites in the

zone could be considered eligible for nomination to the National Register of Historic Places.

4.4.2 Native American Cultural Resources

In conjunction with 1991 studies related to a proposed New Production Reactor, DOE conducted an investigation of Native American concerns over religious rights in the Central Savannah River Valley. During this study three Native American groups - the Yuchi Tribal Organization, the National Council of Muskogee Creek, and the Indian People's Muskogee Tribal Town Confederacy - expressed concerns over sites and items of religious significance on the SRS. DOE has included these organizations on its environmental mailing list and sends them documents about SRS environmental activities (NUS 1991a).

Native American resources in the region include villages or townsites, ceremonial lodges, burial sites, cemeteries, and areas containing traditional plants for certain rituals. Villages or townsites might contain a variety of sensitive features associated with different ceremonies and rituals. The Yuchi and Muskogee Creek tribes have expressed concerns that the area might contain several plants traditionally used in tribal ceremonies (DOE 1993a).

4.4.3 Paleontological Resources

Invertebrate fossil remains occur within the McBean, Barnwell, and Congaree formations of the Eocene Age (54 million to 39 million years ago) on the SRS. Relatively large quantities of marine invertebrate fossils have been recorded for the McBean and Barnwell Formations. Relative assessment of fossil localities is difficult because the South Carolina Geological Survey has not established criteria for, or registry of, important paleontological locations (DOE 1991b).

4.5 Aesthetics and Scenic Resources

The dominant aesthetic setting in the vicinity of the SRS consists mainly of agricultural land and forest, with some limited residential and industrial areas. Because of the distance to the Site boundary, the rolling terrain, normally hazy atmospheric conditions, and heavy vegetation, SRS facilities are not generally visible from off the Site. The few locations that have views of some of the SRS structures are quite distant from the facility [5 miles (8 kilometers) or more].

SRS land is heavily wooded, and developed areas occupy only approximately 5 percent of the total land area. The facilities are scattered across the SRS and are brightly lit at night. Typically, the reactors and principal processing facilities are large concrete structures as much as 100 feet (30 meters) high and usually colocated with lower administrative and support buildings and parking lots. The facilities are visible in the direct line-of-sight when approaching them from SRS access roads. A 500-foot cooling tower is located in K-Area. Otherwise, heavily wooded areas that border the SRS road system and public highways that cross the Site limit views of the facilities.

4.6 Geology

The SRS is on the Upper Atlantic Coastal Plain of South Carolina, which consists of 213 to 366 meters (700 to 1,200 feet) of sands, clays, and limestones of Tertiary and Cretaceous age. These sediments are underlain by sandstones of Triassic age and older metamorphic and igneous rocks (Arnett et al. 1993). There are no known capable faults on the SRS or volcanic activities within 800 kilometers (500 miles) of the Site.

4.6.1 General Geology

The SRS is in the Coastal Plain physiographic province of western South Carolina, approximately 32 kilometers (20 miles) southeast of the Fall Line, which separates the Piedmont and Coastal Plain provinces (Figure 4-3). The Coastal Plain province is underlain by a wedge of seaward-dipping and thickening unconsolidated and semiconsolidated sediments that extend from the Fall Line to the Continental Shelf (Figure 4-4).

In South Carolina, the Coastal Plain province is divided into the Upper Coastal Plain and the Lower Coastal Plain. Subdivisions of the Coastal Plain in the State include the Aiken Plateau and the Congaree Sand Hills in the Upper Coastal Plain, and the Coastal Terraces in the Lower Coastal Plain. The Congaree Sand Hills trend along the Fall Line northeast and north of the Aiken Plateau. The Savannah and Congaree Rivers bound the Aiken Plateau, on which the SRS is located; the plateau extends from the Fall Line to the Coastal Terraces. The surface of the plateau is highly dissected and characterized by broad interfluvial areas with narrow steep-sided valleys. The plateau is generally well drained, although poorly drained depressions (Carolina bays) do exist (DOE 1991b). Because of the proximity of the SRS to the Piedmont province, it has more relief than areas that are nearer to the coast, with onsite elevations ranging from 27 to 128 meters (89 to 420 feet) above mean sea level.

The sediments of the Atlantic Coastal Plain of South Carolina overlie a basement complex composed of Paleozoic crystalline and Triassic sedimentary rocks. These sediments dip gently seaward from the Fall Line and range in age from Late Cretaceous to Recent. The sedimentary sequence thickens from essentially zero at the Fall Line to more than 1,219 meters (4,000 feet) at the coast. Regional dip is to the southeast. Coastal Plain sediments underlying the SRS consist of sandy clays and clayey sands, although occasional beds of clean sand, gravel, clay, or carbonate occur (Figure 4-5). Two clastic limestone zones occur within the Tertiary age sequence. These calcareous zones vary in thickness from about 0.6 meter (2 feet) to approximately 24 meters (80 feet). Most of the clastic sediments are unconsolidated, but thin semiconsolidated beds also occur (DOE 1991b). Underlying sediments are dense crystalline igneous and metamorphic rock or younger consolidated sediments of the Triassic Period. The Triassic formations and older igneous and metamorphic rocks are separated hydrologically from the overlying Coastal Plain sediments by a regional aquitard, the Appleton Confining System (Arnett et al. 1993). Section 4.8.2 contains a detailed discussion of hydrogeology on the SRS.

Figure 4-3. Location of the Savannah River Site in the southern United States. **Figure 4-4. Generalized subsurface cross-section.** **Figure 4-5. Stratigraphy of the SRS region.**

4.6.2 Geologic Resources

SRS construction activities have used clay, sand, and gravel to a limited extent. These materials are not of major economic value due to their abundance throughout the region. The SRS historically has been a major user of groundwater in the region, withdrawing about 33 million liters (9 million gallons) per day. Section 4.8.2 describes the groundwater resources at the SRS.

4.6.3 Seismic and Volcanic Hazards

The closest offsite fault system of significance is the Augusta Fault Zone, approximately 40 kilometers (25 miles) from the SRS. In this fault zone, the Belair Fault has experienced the most recent movement, but it is not considered capable of generating major earthquakes (DOE 1987a). There is no conclusive evidence of recent displacement along any fault within 320 kilometers (200 miles) of the SRS, with the possible exception of the buried faults in the epicentral area of the 1886 earthquake at Charleston, South Carolina, approximately 145 kilometers (90 miles) away (DOE 1991b). Faulting in the subsurface Coastal Plain sediments in the Charleston vicinity has been suggested, based on structure contour mapping of the Eocene-Oligocene unconformity, which lies at a depth of about 30 to 61 meters (100 to 200 feet) below ground surface (WSRC 1994a). However, because it is not known if these faults offset sediments younger than Eocene-Oligocene, these shallow faults cannot be related to modern earthquakes that occur at depths greater than about 1.9

kilometers (1.2 miles). Figure 4-6 shows the geologic structures within 150 kilometers (95 miles) from the SRS, some of which are discussed above.

Several Triassic-Jurassic basins, 140 to 230 million years old, have been identified in the Coastal Plain province of South Carolina and Georgia. The Dunbarton Triassic basin, which underlies a portion of the SRS, was formed by fault movement resulting from extensional forces operating during the formation of the Atlantic Ocean. After the erosion of basin margins and infilling of the basin with Triassic age sediments, possible movement of an opposite sense to that during basin formation occurred along the fault during the Late Cretaceous age. Geophysical data indicate minimal movement on faults at the basement-Coastal Plain interface, with the exception of possible reverse fault motion along the Pen Branch Fault up into the Tertiary (WSRC 1994a).

Figure 4-6. Geologic structures within 150 km of SRS (Source: DOE 1991b).

Researchers have mapped the Pen Branch Fault for at least 24 kilometers (15 miles) across the central portion of the SRS (Snipes et al. 1993). This fault is probably a continuation of the northern boundary fault of the Triassic age Dunbarton basin and is interpreted as being at least a Cretaceous/Tertiary (144-1.6 million years) reactivation of that fault (WSRC 1994a). Observed displacements of the Coastal Plain sediments range from about 26 meters (85 feet) at the Basement/Cretaceous contact to about 9 meters (30 feet) in the shallower sediments (WSRC 1994a). Based on the available data, there is no evidence to indicate that the Pen Branch is a "capable fault" as defined by the U.S. Nuclear Regulatory Commission (NRC). Under the NRC definition, a fault is capable if it has moved within the last 35,000 years, has had recurring movement within the last 500,000 years, is related to any earthquake activity, or is associated with another capable fault. A recent study (Snipes et al. 1993) examined a Quaternary light tan soil horizon in SRS railroad cuts. The soil horizon, which has a thickness of 3 to 6 meters (10 to 20 feet), revealed no detectable offset, indicating that there has been no recent Pen Branch Fault activity. Figure 4-7 shows the locations of the Pen Branch Fault and other known or suspected faults within the Paleozoic and Triassic Basement (DOE 1991b).

Seismicity in the Coastal Plain of South Carolina occurs in three distinct seismic zones near the Charleston area (WSRC 1994a): Middleton Place-Summerville, about 19 kilometers (12 miles) northwest of Charleston; Bowman, about 59 kilometers (37 miles) northwest of the Middleton Place-Summerville; and Adams Run, about 30 kilometers (19 miles) southwest of the Middleton Place-Summerville (WSRC 1994a). Of the distinct seismic zones within the Coastal Plain province, the Charleston area has been and remains the most seismically active. The Charleston area is also the most significant source of seismicity affecting the SRS, both in terms of maximum historic site intensity and the number of earthquakes felt in the area (WSRC 1994a).

Tables 4-2 and 4-3 summarize the historic information on earthquakes that have occurred in the SRS region. Two notable earthquakes have occurred within 320 kilometers (200 miles) of the SRS. The first was a major earthquake in 1886 centered in the Charleston area about 145 kilometers (90 miles) from the Site; it had an estimated Richter magnitude of 6.8. DOE estimates that the SRS would have felt a tremor with an estimated Modified Mercalli Intensity (MMI) of VI to VII and an estimated peak horizontal acceleration of 10 percent of gravity, or 0.10g, due to that earthquake (WSRC 1994a). The second earthquake was the Union County, South Carolina, earthquake of 1913, which had an estimated Richter magnitude of 6.0 and occurred about 160 kilometers (100 miles) from the SRS (WSRC 1994a). This earthquake, which is the closest significant event to the SRS other than

Figure 4-7. Geologic faults of the Savannah River Site.

Table 4-2. Earthquakes in the SRS region with a Modified Mercalli Intensity greater than V.

Date[b]	Location	Coordinates Lat. (yN)	Coordinates Long. (yW)	Maximum Intensity	Distance from SRS (km)[c]	Reported or Estimated Intensity at SRS	Estimated Richter Magnitude	Acceleration at SRS(g)
1811 Jan 13	Burke Co., Ga.	33.2	82.2	V	55	III-IV	NA[d]	0.02
1811-1812 (3 shocks)	New Madrid, Mo.	36.3	89.5	XI-XII	850	V-VI	NA	0.05
1875 Nov 02	Lincolnton, Ga.	33.8	82.5	VI	100	III-IV	NA	0.02

1886 Sep 02	Charleston, S.C.	32.9	80.0	X	145	VI	6.8	0.10
1886 Oct 22	Charleston, S.C.	32.9	80.0	VII	155	III-IV	NA	0.02
1897 May 31	Giles Co., Va.	33.0	80.7	VIII	455	III	NA	0.02
1913 Jan 01	Union Co., S.C.	34.7	81.7	VII-VIII	160	IV	6.0[e]	0.02
1920 Aug 01	Charleston, S.C.	33.1	80.2	VII	135	III-IV	NA	0.02
1972 Feb 03	Bowman, S.C.	33.5	80.4	V	115	IV	4.5	0.02
1974 Aug 02	Willington, S.C.	33.9	82.5	VI	105	IV	4.1	0.02
1974 Nov 22	Charleston, S.C.	32.9	80.1	VI	145	III-IV	4.3	0.02

a. Source: DOE (1991b).
b. Based on Greenwich mean time.
c. Conversion factor: 1 kilometer = 0.6214 mile.
d. NA = data not available.
e. Estimated.

Table 4-3. Earthquakes in the SRS region with a Modified Mercalli Intensity greater than IV or a magnitude greater than 2.0.

Date[b]	Coordinates Lat. (yN)	Long. (yW)	Maximum Intensity	Distance from SRS (km)[c]	Reported or Estimated Intensity at SRS	Estimated Richter Magnitude	Acceleration at SRS(g)
1811 Jan 13[d]	33.2	82.2	V	55	III-IV	NA[e]	0.02
1853 May 20	34.0	81.2	VI	102	NA	NA	NA
1945 Jul 26	33.8	81.4	V	77	NA	4.4	NA
1964 Mar 07	33.7	82.4	NA	85	NA	3.3	NA
1964 Apr 20	33.8	81.1	V	96	NA	3.5	NA
1968 Sep 22	34.1	81.5	IV	102	NA	3.5	NA
1972 Aug 14	33.2	81.4	NA	27	NA	3.0	NA
1974 Oct 28	33.8	81.9	IV	72	NA	3.0	NA
1974 Nov 05	33.7	82.2	III	77	NA	3.7	NA
1976 Sep 15	33.1	81.4	NA	25	NA	2.5	NA
1977 Jun 05	3.1	81.4	NA	35	NA	2.7	NA
1982 Jan 28	32.9	81.4	NA	40	NA	3.4	NA
1985 Jun 08	33.2	81.7	III	Onsite	III	2.6	NA
1988 Feb 17[f]	33.6	81.7	III	45	NA	2.6	NA
1988 Aug 05	33.1	81.4	NA	Onsite	II	2.0	NA
1993 Aug 08	NA	NA	NA	NA	NA	3.2	NA

a. Source: DOE (1991b).
b. Based on Greenwich mean time.
c. Conversion factor: 1 kilometer = 0.6214 mile.
d. Located in Burke County, Ga.
e. NA = data not available.
f. Located at Aiken, S.C.

the Charleston-area earthquake, produced an estimated intensity of II to III (MMI) in the City of Aiken, which is approximately 19 kilometers (12 miles) north of the Site (DOE 1991b; WSRC 1994a).

Two earthquakes have occurred on the SRS during recent years (see Figure 4-7). On June 8, 1985, onsite instruments recorded an earthquake with a Richter magnitude of 2.6 and a focal depth of about 1.0 kilometer (0.6 mile) (WSRC 1994a). The epicenter was just west of the C- and K-Areas. The ground acceleration from this event did not activate instrumentation in the reactor areas (detection limits of 0.002g). On August 5, 1988, an earthquake with a Richter magnitude of 2.0 and a focal depth of approximately 2.7 kilometers (1.7 miles) occurred (Stephenson 1988); earthquakes of Richter magnitude 2.0 are normally detected only by specialized instrumentation. The epicenter for this event was just northeast of K-Area. Although this event was not felt by workers on the SRS, it was recorded by sensors within 96 kilometers (60 miles) of the Site. A report on the August 1988 earthquake (Stephenson 1988) also reviewed the latest earthquake history for the region. This report predicts recurrence period of 1 year for a magnitude 2.0 event for the southeast Coastal Plain. However, the report notes that historic data to calculate recurrence rates accurately are sparse. SRS workers did feel the effects of two other events that occurred in the area within the past 7 years. A Richter magnitude 2.6 earthquake occurred in the City of Aiken, approximately 19 kilometers (12 miles) north of the SRS on February 17, 1988. Reports indicate that this event was felt in the Aiken area and on the SRS (DOE 1991b). Most recently, a Richter magnitude 3.2 earthquake occurred on August 8, 1993, approximately 16 kilometers (10 miles) east of the City of Aiken near Couchton, South Carolina. Residents reported feeling this earthquake in Aiken, New Ellenton (immediately north of the SRS), North Augusta (approximately 40 kilometers [25 miles] northwest of the SRS), and the Site.

Based on seismic activity information in the past 300 years, this analysis does not project earthquakes greater than a Richter magnitude 6.0, which corresponds to a Modified Mercalli Intensity of VII, to occur on the SRS. The design-basis earthquake for the SRS is a Modified Mercalli Intensity VIII event, which corresponds to a horizontal peak ground acceleration of 0.2g. Based on current technology, as applied in various probabilistic evaluations of the seismic hazard in the SRS region, the 0.2g peak ground acceleration can be associated with a 2 x 10-4 annual probability of exceedance (5,000-year return period). DOE Standards 1020 (DOE 1994a) and 1024 (DOE 1992) summarize the results of recent seismic analyses at DOE sites and show that maximum horizontal ground accelerations for the Savannah River Site for 500 year, 1,000 year, 2,000 year, and 5,000 year seismic events are 0.10g, 0.13g, 0.18g, and 0.19g respectively. The seismic hazard information presented in this EIS is for general seismic hazard comparisons across DOE sites. Potential seismic hazards for existing and new facilities should be evaluated on a facility-specific basis consistent with DOE Orders and standards and site-specific standards.

Historically, DOE has generally selected the more conservative 0.20g as the peak ground acceleration for the 5,000 year seismic event when preparing safety analysis reports and environmental impact statements for the SRS. For consistency with these existing analyses, this environmental impact statement assumes 0.20g to be the peak horizontal ground acceleration that would result from the 5,000 year seismic event. Figure 4-8 shows seismic hazard curves for the SRS.

A number of paleoliquefaction sites have been identified in Beaufort County, South Carolina, some 50 miles (80 kilometers) southeast of the SRS, indicating a likelihood of prehistoric seismic events outside of the currently-active Charleston seismic zone (Rajendran and Talwani 1993). There is no evidence to suggest that seismically-induced liquefaction of soils represents a hazard at SRS, however. Weak subsurface zones are encountered occasionally during drilling. These zones are associated with carbonate materials and appear to be related to dissolution of these materials.

Engineering investigations have been conducted on granular soils underlying the Defense Waste Processing Facility [in S-Area just north of H-Area (see Figure 2-3)] to evaluate the cyclic mobility (liquefaction under cyclic stresses) of these soils (WSRC 1992b). These investigations determined that the sands and clayey sands throughout the subgrade will not experience liquefaction (strength loss leading to bearing capacity failures) and will not develop cyclic mobility (significant cyclic or accumulate deformations) under the safe shutdown earthquake with a peak horizontal ground surface acceleration of 0.20g (9.8 meters/second2 or 32.1 feet/second2).

4.7 Air Resources

4.7.1 Meteorology and Climatology

The SRS collects wind data from instruments mounted on seven onsite 61-meter (200-foot) meteorological towers. Figure 4-9 shows a wind rose that represents annual wind direction frequencies and wind speeds for the SRS from 1987 through 1991. The maximum wind directional frequencies are from the northeast and west-southwest. The average wind speed for this 5-year period was 3.8 meters per second (8.5 miles per hour). Calm winds (less than 1 meter per second or 2.2

miles per hour) occurred less than 10 percent of the time during the 5-year period. Seasonally, wind speeds were greatest during the winter at 4.1 meters per second (9.5 miles per hour) and lowest during the summer at 3.4 meters per second (7.6 miles per hour) (WSRC 1994a).

Figure 4-8. Seismic hazard curves for the SRS. Figure 4-9. Wind Rose.

The annual average temperature at the SRS is 18 degrees C (64 degrees F); monthly averages range from a low of 7 degrees C (45 degrees F) in January to a high of 27 degrees C (81 degrees F) in July. Relative humidity readings taken four times each day range from 36 percent in April to 98 percent in August (DOE 1991a).

The average annual precipitation at the SRS is approximately 122 centimeters (48 inches). Precipitation distribution is fairly even throughout the year, with the highest precipitation in the summer [36.1 centimeters (14.2 inches)] and the lowest in autumn [22.4 centimeters (8.8 inches)]. Snowfall has occurred in the months of October through March, with the average annual snowfall at 3.0 centimeters (1.2 inches). Large snowfalls are rare (DOE 1991a).

Winter storms in the SRS area occasionally bring strong and gusty surface winds with speeds as high as 32 meters per second (72 miles per hour). Thunderstorms can generate winds with speeds as high as 18 meters per second (40 miles per hour) and even stronger gusts. The fastest 1-minute wind speed recorded at Augusta between 1950 and 1986 was 37 meters per second (83 miles per hour) (DOE 1991a).

4.7.1.1 Occurrence of Violent Weather. The SRS area experiences an average of 56 thunderstorm days per year. From 1954 to 1983, 37 tornadoes were reported for a 1-degree square of latitude and longitude that includes the SRS (DOE 1991a). This frequency of occurrence is equivalent to an average of about one tornado per year. The estimated probability of a tornado striking a point on the SRS is 7 x 10-5 per year (DOE 1991a). Since operations began at the SRS in 1953, nine confirmed tornadoes have occurred on or near the Site. They caused nothing more than light damage, with the exception of a tornado in October 1989 that caused considerable damage to forest resources in an undeveloped southeastern sector of the SRS (WSRC 1994a).

From 1700 to 1992, 36 hurricanes occurred in South Carolina, resulting in an average frequency of about one hurricane every 8 years. Three hurricanes were classified as major. Because SRS is about 160 kilometers (100 miles) inland, the winds associated with hurricanes have usually diminished below hurricane force [i.e., equal to or greater than a sustained wind speed of 33.5 meters per second (75 miles per hour)] before reaching the SRS. Winds exceeding hurricane force have been observed only once at SRS (Hurricane Gracie in 1959) (WSRC 1994a).

4.7.1.2 Atmospheric Stability. Based on measurements at onsite meteorological stations, the atmosphere in the SRS region is unstable approximately 56 percent of the time, neutral 23 percent of the time, and stable about 21 percent of the time. On an annual basis, inversion conditions occur 21 percent of the time at the SRS (WSRC 1994a).

4.7.2 Nonradiological Air Quality

4.7.2.1 Background Air Quality. The SRS is in the Augusta (Georgia) - Aiken (South Carolina) Interstate Air Quality Control Region (AQCR). This Air Quality Control Region, which is designated as a Class II area, is in compliance with National Ambient Air Quality Standards (NAAQS) for criteria pollutants. The criteria pollutants include sulfur dioxide, nitrogen oxides reported as nitrogen dioxide, particulate matter (less than or equal to 10 microns), carbon monoxide, ozone, and lead (CFR 1993a). The closest nonattainment area to the SRS is the Atlanta, Georgia, air quality region, 233 kilometers (145 miles) to the west, which is in nonattainment of the standard for ozone.

The SRS will have to comply with Prevention of Significant Deterioration (PSD) Class II requirements if there is a significant increase in emissions of criteria air pollutants due to a modification at the Site (CFR 1993b). Development at the SRS has not yet triggered Prevention of Significant Deterioration permitting requirements. If a permit were required, the SRS would have to address several requirements, including impacts on the air quality of Class I areas within 10 kilometers (6.2 miles) of the Site (CFR 1993b). The nearest Class I area to the SRS is the Congaree Swamp National Monument in South Carolina, approximately 73 kilometers (45 miles) to the east-northeast of the Site. Therefore, a Prevention of Significant Deterioration permit, if required for the SRS, would not have to address Class I areas.

4.7.2.2 Air Pollutant Source Emissions. The SRS utilized the 1990 comprehensive

emissions inventory data to establish the baseline year for showing compliance with State and Federal air quality standards - calculating both maximum potential and actual emission rates. The air quality compliance demonstration also included sources forecast for construction or operation in this decade (for which the SRS had obtained air quality construction permits through December 1992). The SRS based its calculated emission rates for the sources on process knowledge, source testing, permitted operating capacity, material balance, and U.S. Environmental Protection Agency (EPA) Air Pollution Emission Factors (AP-42; EPA 1985).

4.7.2.3 Ambient Air Monitoring. At present, the SRS performs no onsite ambient air quality

monitoring. State agencies operate ambient air quality monitoring sites in Barnwell, Aiken, and Richmond Counties. These areas, which include the SRS, are in attainment with National Ambient Air Quality Standards for sulfur dioxide, nitrogen oxides, carbon monoxide, particulate matter, ozone, and lead (CFR 1993a).

4.7.2.4 Atmospheric Dispersion Modeling. The SRS has performed atmospheric

dispersion modeling for criteria and toxic air pollutants for both maximum potential and actual emissions for the base year 1990, using the EPA Industrial Source Complex Short Term No. 2 Model. The SRS used 1991 meteorological data collected at the Site meteorological stations for input to the model.

4.7.2.5 Summary of Nonradiological Air Quality. The SRS is in compliance with

National Ambient Air Quality Standards and with the gaseous fluoride and total suspended particulate standards required by South Carolina Department of Health and Environmental Control (SCDHEC) Regulation R.61-62.5, Standard 2, "Ambient Air Quality Standards" (AAQS) (see Table 4-4).

The SCDHEC has non-radiological air quality regulatory authority over the SRS. The Department determines SRS ambient air quality compliance based on SRS air pollutant emissions modeled at the Site perimeter (excluding SC Highway 125, which crosses the southwestern quadrant of the SRS).

The SRS is in compliance with SCDHEC Regulation R.61-62.5, Standard 8, "Toxic Air Pollutants," which regulates the emission of 257 toxic substances. The SRS has identified emission sources for 139 of the 257 regulated substances; the modeled results indicate that the Site is within applicable Department of Health and Environmental Control standards (WSRC 1993a). Table 4-5 lists

SRS emissions of toxic air pollutants of concern related to the SRS spent nuclear fuel alternatives, based on 1990 baseline data and the potential sources of air pollution permitted for construction or operation in December 1992.

4.7.3 Radiological Air Quality

4.7.3.1 Background and Baseline Radiological Conditions. In the SRS region, airborne

radionuclides originate from natural resources (terrestrial or cosmic), worldwide fallout, and Site operations. The SRS maintains a network of air monitoring stations on and around the Site to

Table 4-4. Estimated ambient concentration contributions of criteria air pollutants from existing SRS sources and sources planned for construction or operation through 1995 (-g/m3). ,b

Pollutantc	Averaging time	SRS Maximum Potential Concentration	Actual	Most stringent AAQSd (Federal or state)	Maximum Potential Concentration as a Percent of AAQSe
SO2	Annual	18	10	80f	22.5
	24-hour	356	185	365f,g	97.5
	3-hour	1,210	634	1,300f,g	93
NOx	Annual	30	4	100f	30
CO	8-hour	818	23	10,000f,g	8
	1-hour	3,553	180	40,000f,g	9
Gaseous fluorides (as HF)	12-hour	2.40	0.62	3.7e	65
	24-hour	1.20	0.31	2.9e	41
	1-week	0.6	0.15	1.6e	38
	1-month	0.11	0.03	0.8e	14
PM10	Annual	9	3	50f	18
	24-hour	93	56	150f	62
O3	1-hour	NA	NA	235f,g	NA
TSP	Annual geometric mean	20	11	75e	2.7
Lead	Calendar quarter mean	0.0015	0.0003	1.5e	0.1

a. Source: WSRC (1994b).
b. The contributions listed are the maximum values at the SRS boundary.
c. SO2 = sulfur dioxide; NOx = nitrogen oxides; CO = carbon monoxide; PM10 = particulate matter < 10-m in diameter; TSP = Total Suspended Particulates, O3 = Ozone.
d. AAQS = Ambient Air Quality Standard.
e. Source: SCDHEC (1976).
f. Source: 40 CFR Part 50.
g. Concentration not to be exceeded more than once a year.
NA = Not available.

Table 4-5. Baseline 24-hour average modeled concentrations at the SRS boundary - toxic air pollutants regulated by South Carolina from existing SRS sources and sources planned for construction or operation through 1995 (yg/m3).

Pollutantb	Regulatory Limit	Maximum Potential Concentrationc	Actual Concentrationd	Maximum Potential Concentration as a Percent of AAQSe
Nitric acid	125	51	4.0	41
1,1,1-Trichloroethane	9,550	81	22	1
Benzene	150	32	31	21
Ethanolamine	200	<0.01	<0.01	<0.1
Ethyl benzene	4,350	0.58	0.12	<0.1
Ethylene glycol	650	0.20	0.08	<0.1
Formaldehyde	7.5	<0.01	<0.01	<0.1
Glycol ethers	Pending	<0.01	<0.01	-
Hexachloronapthalene	1	<0.01	<0.01	<0.1
Hexane	200	0.21	0.072	<0.1
Manganese	25	0.82	0.10	3
Methyl alcohol	1,310	2.9	0.51	0.2

Methyl ethyl ketone	14,750	6.0	0.99	<0.1
Methyl isobutyl ketone	2,050	3.0	0.51	<0.1
Methylene chloride	8,750	10.5	1.8	<0.1
Naphthalene	1,250	0.01	0.01	<0.1
Phenol	190	0.03	0.03	<0.1
Phosphorus	0.5	<0.001	<0.001	<0.1
Sodium hydroxide	20	0.01	0.01	<0.1
Toluene	2,000	9.3	1.6	<0.1
Trichloroethylene	6,750	4.8	1.0	<0.1
Vinyl acetate	176	0.06	0.02	<0.1
Xylene	4,350	39	3.8	0.9

a. Source: WSRC (1994b).
b. Pollutants listed include compounds of interest regarding spent nuclear fuel alternatives.
c. Maximum potential emissions from all SRS sources for 1990 plus maximum potential emissions for sources permitted in 1991 and 1992.
d. Actual emissions from all SRS sources plus maximum potential emissions for sources permitted for construction through December 1992.
e. AAQS = Ambient Air Quality Standard.

determine concentrations of radioactive particulates and aerosols in the air (Arnett et al. 1992).

Table 4-6 lists average and maximum atmospheric radionuclide concentrations at the SRS boundary **and background [160-kilometer (100-mile) radius] monitoring locations during 1991.** Table 4-7 lists the average concentrations of tritium in the atmosphere, as measured at on- and offsite monitoring locations.

Table 4-6. Radioactivity in air at SRS perimeter and at 160-kilometer (100-mile) radius (pCi/m3).

Location	Gross Alpha	Nonvolatile Beta	Sr-89,90b	Pu-238b	Pu-239b
Site perimeter					
Average	2.61x10-3	1.78x10-2	4.90x10-5	1.22x10-6	2.11x10-6
Maximum	1.07x10-2	4.63x10-2	5.11x10-4	1.94x10-5	5.40x10-5
Background (160-kilometer radius)					
Average	2.60x10-3	1.76x10-2	2.00x10-4	1.44x10-6	6.10x10-7
Maximum	9.31x10-3	5.26x10-2	2.08x10-3	2.39x10-5	5.40x10-6

a. Source: Arnett et al. (1992).
b. Monthly composite.

Table 4-7. Average atmospheric tritium concentrations on and around the Savannah River Site (pCi/m3).

Location	1991	1990	1989
Onsite	250	430	640
Site perimeter	21	32	37
40-kilometer radius	11	12	14
160-kilometer radius	8.5	8.8	9

a. Source: Arnett et al. (1992).

4.7.3.2 Sources of Radiological Emissions. Table 4-8 lists groups of facilities that

released radionuclides to the atmosphere in 1992; the facilities are grouped according to the principal function that resulted in the release of radioactive materials.

Table 4-9 lists both the identified radionuclides that contributed to the SRS dose and the percent contribution of each radionuclide to the total site effective dose equivalent.

Table 4-8. Operational groupings and function of radionuclide sources.

Group	Function
Reactor Materials	Production of fuel and targets
Reactors	Irradiation of fuel and targets
Separations	Separation of useful radionuclides (other than tritium)
Analytical Laboratories	Process Control Laboratories
Tritium	Extraction, purification, and packaging
Waste Management	Management of radioactive waste
Savannah River Technology Center	Research and development to support SRS processes

4.8 Water Resources

4.8.1 Surface Water

The Savannah River bounds the SRS on its southwestern border for about 20 miles (32 kilometers), approximately 160 river miles (260 kilometers) from the Atlantic Ocean. At the SRS, river flow averages about 10,000 cubic feet (283 cubic meters) per second. River flows range from 3,960 cubic feet (112 cubic meters) per second to 71,700 cubic feet (2,030 cubic meters) per second.

Five upstream reservoirs - Jocassee, Keowee, Hartwell, Richard B. Russell, and Strom Thurmond - minimize the effects of droughts and the impacts of low flow on downstream water quality and fish and wildlife resources in the river.

At the SRS, a swamp occupies the floodplain along the Savannah River for a distance of approximately 10 miles (17 kilometers); the swamp is about 1.5 miles (2.5 kilometers) wide. A natural levee separates the river from the swampy floodplain. Figure 4-10 shows the 100-year floodplain of the Savannah River in the vicinity of the SRS as well as the floodplains of major tributaries draining the SRS. A 500-year floodplain map of the SRS has not been completed, but would be required prior to the siting of any spent nuclear fuel management facilities, in compliance with DOE regulations (CFR 1979). These regulations require DOE to evaluate the potential effects of flooding to proposed "critical actions" (for example, the storage of highly toxic or water-reactive materials), which it defines as those for which even a slight chance of flooding would be unacceptable.

The five principal tributaries to the river on the SRS are Upper Three Runs Creek, Fourmile Branch, Pen Branch, Steel Creek, and Lower Three Runs Creek (Figure 4-10). These tributaries drain almost all of the SRS. Each of these streams originates on the Aiken Plateau in the Coastal Plain and descends 50 to 200 feet (15 to 60 meters) before discharging into the river. The streams, which historically have received varying amounts of effluent from various SRS operations, are not commercial sources of water. The natural flow of SRS streams ranges from less than 10 cubic feet (l cubic meter) per second in smaller streams such as Pen Branch to 240 cubic feet (6.8 cubic meters) per second in Upper Three Runs Creek.

Table 4-9. Annual quantity of radionuclide emissions from the Savannah River Site. ,b

Radionuclide	Annual Quantity (curies)	Percent of Total Site Dose
H-3 (oxide)	1.00x105	98.0
Pu-239	7.45x10-4	0.6
U-235,238	1.58x10-3	0.4
Pu-238	4.46x10-4	0.3
Ar-41	2.51x102	0.3
I-129	3.50x10-3	0.2
Am-241,243	1.13x10-4	0.1
Sr-89,90 (Y-90)	2.03x10-3	0.02
Cm-242,244	2.31x10-5	0.01
Cs-137 (Ba-137m)	2.50x10-4	0.01
C-14	1.86x10-1	0.01
H-3 (elemental)	5.59x104	<0.01
I-135	1.34x10-1	<0.01
Kr-85	4.99x101	<0.01
I-131	9.99x10-5	<0.01
Ru-106 (Rh-106)	1.81x10-6	<0.01
I-133	1.15x10-3	<0.01
Co-60	3.60x10-7	<0.01
Xe-135	2.43x10-3	<0.01
Cs-134	3.75x10-8	<0.01
Ce-144 (Pr-144,144m)	1.16x10-7	<0.01
Eu-154	3.44x10-13	<0.01
Eu-155	1.63x10-13	<0.01
Sb-125	7.27x10-15	<0.01
Zr-95 (Nb-95)	2.39x10-14	<0.01

a. Source: Arnett et al. (1993).
b. Includes emissions to the atmosphere and surface water.

Figure 4-10. Savannah River Site, showing major stream systems and facilities.

4.8.1.1 SRS Streams.

This section describes the pertinent physical and hydrologic properties of Upper Three Runs Creek and Fourmile Branch, which are the streams closest to most SRS spent nuclear fuel management locations (Figure 4-10). These two streams are among the largest on the SRS, and they border the areas where DOE is most likely to locate new spent nuclear fuel facilities.

Upper Three Runs Creek is a large, cool [annual maximum temperature of 26.1 degrees C

(79 degrees F)] blackwater stream in the northern part of the SRS. It drains an area of approximately 210 square miles (545 square kilometers), and has an average discharge of 330 cubic feet (9.3 cubic meters) per second at the mouth of the creek. Upper Three Runs Creek is approximately 25 miles (40 kilometers) long, with its lower 17 miles (28 kilometers) inside the boundaries of the SRS. This creek receives more water from underground sources than the other SRS streams and, therefore, has low conductivity, hardness, and pH values. Upper Three Runs Creek is the only major tributary on the SRS that has never received thermal discharges.

Fourmile Branch is about 15 miles (24 kilometers) long and drains an area of approximately 34 square miles (89 square kilometers). In its headwaters, Fourmile Branch is a small blackwater stream that receives relatively few impacts from SRS operations. The water chemistry in the headwater area of the creek is very similar to that of Upper Three Runs Creek, with the exception of nitrate concentrations, which are an order of magnitude higher than those in Upper Three Runs Creek (WSRC 1994a). These elevated nitrate concentrations are probably the result of groundwater transport and outcropping from the F- and H-Area seepage basins. In its lower reaches, Fourmile Branch broadens and flows through a delta formed by the deposition of sediments. Although most of the flow through the delta is in one main channel, the delta has many standing dead trees, logs, stumps, and cypress trees that provide structure and reduce the water velocity in some areas. Downstream of the delta, the creek flows in one main channel and most of the flow discharges into the Savannah River at River Mile 152 (kilometer 245), while a small portion of the creek flows west and enters Beaver Dam Creek, a small onsite tributary.

4.8.1.2 Surface Water Quality. The Savannah River, which forms the boundary between the States of Georgia and South Carolina, supplies potable water to several users. Upstream of the SRS, the river supplies domestic and industrial water needs for Augusta, Georgia, and North Augusta, South Carolina. The river also receives sewage treatment plant effluent from Augusta, Georgia; North Augusta, Aiken, and Horse Creek Valley, South Carolina; and as described above from a variety of SRS operations via onsite stream discharges. Approximately 130 river-miles (210 kilometers) downstream of the SRS, the river supplies domestic and industrial water needs for Savannah, Georgia, and Beaufort and Jasper Counties in South Carolina through intakes located at about River Mile 29 and River Mile 39. In addition, Georgia Power's Vogtle Electric Generating Plant withdraws an average of 1.3 cubic meters per second (46 cubic feet per second) for cooling and returns an average of 0.35 cubic meters per second (12 cubic feet per second) of cooling tower blowdown. Also, the Urquhart Steam Generating Station at Beech Island, South Carolina withdraws approximately 7.5 cubic meters per second (265 cubic feet per second) for once-through cooling water.

The South Carolina Department of Health and Environmental Control regulates the physical properties and concentrations of chemicals and metals in SRS effluents under the National Pollutant Discharge Elimination System (NPDES) program. This agency also regulates chemical and biological water quality standards for SRS waters. On April 24, 1992, the agency changed the classification of the Savannah River and SRS streams from "Class B waters" to "Freshwaters." The definitions of Class B waters and Freshwaters are the same, but the Freshwaters classification imposes a more stringent set of water quality standards (Arnett et al. 1993). Tables 4-10 and 4-11 list the characteristics of SRS surface-water quality upstream and downstream, respectively, due to contributions from SRS and possibly other sources. A comparison of these results indicates that influences from SRS or other sources are not seriously degrading Savannah River water quality.

4.8.2 Groundwater Resources

4.8.2.1 Hydrostratigraphic Units. There are two hydrogeologic provinces in the subsurface beneath SRS (WSRC 1994a). The first, referred to as the Piedmont hydrogeologic province (Figure 4-11), includes Paleozoic metamorphic and igneous basement rocks and Triassic-aged lithified mudstone, sandstone, and conglomerate contained within the Dunbarton Basin. The second, referred to as the Southeastern Coastal Plain hydrogeologic province, represents the major aquifer systems and consists of a wedge of unconsolidated Coastal Plain sediments of Late Cretaceous and Tertiary age (Figure 4-11). These two units are overlain by the vadose or unsaturated zone, which extends from

Table 4-10. Water quality in the Savannah River above the confluence with Upper Three Runs near the Savannah River Site in 1990. ,b

			Existing Water-Body Concentrationf	
Parameter	Unit of Measure	MCL c,d or DCGe	Average	Maximum
Aluminum	mg/L	0.05-0.2g	NCi	1.1
Ammonia	mg/L	NAj	0.1	0.2
Cadmium	mg/L	0.005g	NC	<0.01
Calcium	mg/L	NA	NC	4.4
Cesium-137	pCi/L	120e	0.0088	0.030
Chemical oxygen demand	mg/L	NA	9.7	17
Chloride	mg/L	250h	7.8	11
Chromium	mg/L	0.1d	NC	<0.02
Copper	mg/L	1.0d	NC	<0.01
Dissolved oxygen	mg/L	>5	8.0	9.6
Fecal coliform	Colonies per 100/ml	1,000g	54	197
Gross alpha	pCi/L	15g	0.04	0.36
Ironc	mg/L	0.3h	NC	1.5
Lead	mg/L	0.015g	NC	0.27
Magnesium	mg/L	NA	NC	1.4
Manganesec	mg/L	0.05g	NC	0.12
Mercury	mg/L	0.002d	NC	<0.0002
Nickel	mg/L	0.1c	NC	<0.05
Nitrite/Nitrate	mg/L	10g	0.32	0.99
Nonvolatile beta (dissolved)	pCi/L	50g	1.9	3.6
pH	pH Units	6.5-8.5g	Not reported	7.4
Phosphate	mg/L	N/A	0.09	0.16
Plutonium-238	pCi/L	1.6e	0.0006	0.0021
Plutonium-239	pCi/L	1.2e	0.0005	0.0021
Sodium	mg/L	NA	NC	11
Strontium-89	pCi/L	800e	0.23	1.0
Strontium-90	pCi/L	8c	0.09	0.22
Sulfate	mg/L	250h	7.8	11
Suspended solids	mg/L	NA	13	22
Temperature	Degrees Celsius	32.2k	18.0	27
Total dissolved solids	mg/L	500h	62	76
Tritium	pCi/L	20,000c	150	1,110
Zinc	mg/L	5h	NC	0.02

a. Source: Cummins et al. (1991).

b. Parameters are those for which DOE routinely measures as a regulatory requirement or as part of ongoing monitoring programs.

c. Maximum Contaminant Level (MCL), EPA National Primary Drinking Water Regulations (CFR 1974).

d. Maximum Contaminant Level (MCL); South Carolina (1976).

e. U.S. Department of Energy Derived Concentration Guides (DCGs) for Water (DOE 1993b). DCG values are based on committed effective dose of 100 millirem per year; however, because drinking water MCL is based on 4 millirem per year, number listed is 4 percent of DCG.

f. Average concentration of samples taken at downstream monitoring station. Maximum is highest sampled concentration along reach of river potentially affected by site activities. Less than (<) indicates concentration below analysis detection limit.

g. Concentration exceeded water quality criteria; however, these criteria are listed for comparison only. Similarly, drinking water standards and DOE DCGs are listed. Water Quality Criteria (WQCs) and secondary standards are not legally enforceable.

h. Secondary Maximum Contaminant Level (SMCL), EPA National Secondary Drinking Water Regulations (CFR 1991).

i. NC = Not calculated due to insufficient number of samples.

j. NA = None applicable.

k. Shall not exceed weekly average of 32.2 degrees Celsius after mixing nor rise more than 2.8 degrees Celsius in 1 week unless appropriate temperature criterion mixing zone has been established.

Table 4-11. Water quality in the Savannah River below the confluence with Lower Three Runs near the Savannah River Site in 1990. ,b

Parameter	Unit of Measure	MCL c,d or DCGe	Existing Water-Body Concentrationf	
			Average	Maximum
Aluminum	mg/L	0.05-0.2g	NCi	1.1
Ammonia	mg/L	NAj	0.1	0.2
Cadmium	mg/L	0.005g	NC	<0.01
Calcium	mg/L	NA	NC	4.4
Cesium-137	pCi/L	120e	0.028	0.037
Chemical oxygen demand	mg/L	NA	9.8	14
Chloride	mg/L	250h	8	10
Chromium	mg/L	0.1d	NC	<0.02
Copper	mg/L	1.0d	NC	<0.01
Dissolved oxygen	mg/L	>5	7.7	9.5
Fecal coliform	Colonies per 100/ml	1,000g	54	197
Gross alpha	pCi/L	15g	0.08	1.48
Ironc	mg/L	0.3h	NC	1.5
Lead	mg/L	0.015g	NC	0.01
Magnesium	mg/L	NA	NC	1.3
Manganesec	mg/L	0.05h	NC	0.1
Mercury	mg/L	0.002d	NC	<0.0002
Nickel	mg/L	0.1c	NC	<0.05
Nitrite/Nitrate	mg/L	10g	0.28	0.43
Nonvolatile beta (dissolved)	pCi/L	50g	2.1	5.1
pH	pH Units	6.5-8.5h	Not reported	8.2
Phosphate	mg/L	N/A	0.1	0.16
Plutonium-238	pCi/L	1.6e	0.0006	0.0029
Plutonium-239	pCi/L	1.2e	0.0014	0.0079
Sodium	mg/L	NA	NC	11
Strontium-89	pCi/L	800e	0.25	

				0.98
Strontium-90	pCi/L	8c	0.13	0.30
Sulfate	mg/L	250h	8.5	12
Suspended solids	mg/L	NA	12	19
Temperature	Degrees Celsius	32.2k	18.0	27
Total dissolved solids	mg/L	500h	63	71
Tritium	pCi/L	20,000c	900	6,810
Zinc	mg/L	5h	NC	0.02

a. Source: Cummins et al. (1991).
b. Parameters are those for which DOE routinely measures as a regulatory requirement or as part of ongoing monitoring programs.
c. Maximum Contaminant Level (MCL), EPA National Primary Drinking Water Regulations (CFR 1974).
d. Maximum Contaminant Level (MCL); South Carolina (1976).
e. U.S. Department of Energy Derived Concentration Guides (DCGs) for Water (DOE 1993b). DCG values are based on committed effective dose of 100 millirem per year; however, because drinking water MCL is based on 4 millirem per year, number listed is 4 percent of DCG.
f. Average concentration of samples taken at downstream monitoring station. Maximum is highest sampled concentration along reach of river potentially affected by site activities. Less than (<) indicates concentration below analysis detection limit.
g. Concentration exceeded water quality criteria; however, these criteria are listed for comparison only. Similarly, drinking water standards and DOE DCGs are listed. Water Quality Criteria (WQCs) and secondary standards are not legally enforceable.
h. Secondary Maximum Contaminant Level (SMCL), EPA National Secondary Drinking Water Regulations (CFR 1991).
i. NC = Not calculated due to insufficient number of samples.
j. NA = None applicable.
k. Shall not exceed weekly average of 32.2 degrees Celsius after mixing nor rise more than 2.8 degrees Celsius in 1 week unless appropriate temperature criterion mixing zone has been established.

Figure 4-11. Comparison of lithostratigraphy and hydrostratigraphy for the SRS region (not to scale). the ground surface to the water table. The unsaturated zone is a heterogeneous unit of clean, clayey, or silty sand through which recharge takes place.

The sediments that make up the Southeastern Coastal Plain hydrogeologic province in west-central South Carolina are grouped into three major aquifer systems divided by two major confining systems, all of which are underlain by the Appleton confining system (Figure 4-11). The Appleton system separates the Southeastern Coastal Plain hydrogeologic province from the underlying Piedmont hydrogeologic province. Locally, each of the major aquifer systems contains individual aquifer and confining units. Figure 4-11 shows the regional lithostratigraphy of the geologic province with the attendant primary hydrostratigraphic subdivision of the province. The complexly interbedded strata that form the three aquifer systems consist primarily of fine- to coarse-grained sand and local gravel and limestone deposited under relatively high energy conditions in fluvial to shallow marine environments (WSRC 1994a).

Figure 4-11 shows the current aquifer/aquitard terminology at the SRS. Aquifers, in ascending order, include the McQueen Branch, the Crouch Branch, and the Steed Pond. For comparison, the figure also includes the corresponding aquifer terminology used on the Georgia side of the Savannah River. These include the Midville, Dublin, and Floridan aquifer systems. In addition, the three aquifers are separated by confining layers which include, in ascending order, the Appleton, Allendale, and Meyers Branch confining systems (WSRC 1994a).

4.8.2.2 Groundwater Flow. Excellent quality groundwater is abundant in this region of

South Carolina from many local aquifer units. As a result, the South Carolina Department of Health and Environmental Control has classified all aquifers in the state as Class GB (South Carolina 1976), or U.S. Environmental Protection Agency (EPA) Class II, meaning that the aquifers can provide resource-quality water, but are not the sole source of supply (South Carolina Class GA or EPA Class I aquifers) (DOE 1991b).

The main source of recharge to the vadose zone is rainfall. The annual precipitation at the SRS is 48 inches (121.9 centimeters), with an estimated 16 inches (41 centimeters) designated as surface recharge at the center of the SRS, in bare and grass-covered areas (WSRC 1994a). The direction of groundwater flow in the vadose zone is predominantly downward. However, given the lenses of silt and clay that exist, there is significant lateral spread in some areas. In general, the vadose zone thickness ranges from approximately 130 feet (40 meters) in the northernmost portion of the SRS to 0 feet where the water table intersects wetlands, streams, or creeks.

The following discussion of groundwater flow in the Coastal Plain hydrogeologic province begins with the deepest aquifers at the SRS and proceeds to shallower units. It does not address flow in the confining units because few hydraulic head measurements are available for these units and, to a good approximation, flow in aquitards is limited predominantly to vertical flow between aquifer units.

The Midville or McQueen Branch aquifer (which has also been called the Middendorf, the Lower Cretaceous, the Tuscaloosa, and Aquifer IA) is highly transmissive and, therefore, serves in part as the production aquifer for much of the SRS. This aquifer flows horizontally, predominantly toward the Savannah River. In the past, groundwater production wells at the SRS were screened in both the Midville (McQueen Branch) and Dublin (Crouch Branch) aquifers. In 1985 DOE committed to the South Carolina Department of Health and Environmental Control to complete production wells only in the McQueen Branch aquifer to minimize the potential for contamination to reach such wells and spread in the deeper aquifers.

Flow in the Dublin or Crouch Branch aquifer (which has also been called the Black Creek, the Tuscaloosa, the Upper Cretaceous, and Aquifer IB) is more complicated than flow in the deeper McQueen Branch aquifer because of the apparent communication with Upper Three Runs Creek on the SRS. Nonetheless, horizontal flow in the Dublin (Crouch Branch) aquifer is predominantly toward the Savannah River. However, there is an upward vertical flow component near the river and Upper Three Runs Creek. Recharge to the Dublin-Midville aquifer system occurs in areas exposed at the ground surface near the Fall Line (see Figure 4-3).

Horizontal flow in the Gordon aquifer (previously called the Congaree, the Tertiary, and Aquifer II) is toward Upper Three Runs Creek and the Savannah River, depending on the area of the SRS. Both the river and Upper Three Runs Creek intercept this aquifer. The Gordon aquifer receives most of its recharge from groundwater that originates on the SRS.

Previous SRS studies have called the Upper Three Runs aquifer the "water table aquifer"; others have defined it as both the Barnwell/McBean and water table aquifers in the central portion of the SRS where those aquifers were thought to be separated by a "tan clay." The Upper Three Runs aquifer is the shallowest aquifer at the SRS. The horizontal groundwater flow is generally toward the nearest surface-water feature that is in communication with the water table. Most SRS streams, except Tims Branch in the northeastern part of the Site, are in communication with the water table. Tims Branch is a "losing stream," meaning it provides, or "loses," water to the Upper Three Runs aquifer. However, the Upper Three Runs aquifer receives most of its recharge from precipitation. The Upper Three Runs aquifer is not a source of domestic or production water on the SRS because the lower aquifers provide a more abundant supply of higher quality water (WSRC 1994a).

4.8.2.3 Groundwater Quality. The quality of groundwater in the principal hydrologic systems beneath the SRS depends on both the source of the water and the inorganic and biochemical reactions that take place along its flowpath. Quality is strongly influenced by the chemical composition and mineralogy of the enclosing geologic materials (WSRC 1994a).

In general, the quality of the groundwater in the Coastal Plain sediments at the SRS and the surrounding areas is suitable for most domestic and industrial purposes. The waters have low concentrations of total dissolved solids (TDS), ranging from less than 10 milligrams per liter to about 150 to 200 milligrams per liter. The pH values range from 4.9 to 7.7 (where the groundwater is in contact with limestone). Much of the groundwater is corrosive to metal surfaces due to its low solids content and frequently low pH values. High dissolved iron concentrations can also be of concern in some groundwater units. The SRS uses degasification and filtration processes to raise the pH and remove iron in domestic water supplies where necessary (WSRC 1994a).

Table 4-12 summarizes groundwater quality data from 85 existing waste sites on the SRS compared to drinking water standards; Table 4-13 lists similar information for selected radiological constituents. The data in these tables are from ongoing monitoring programs on the Site. EPA-accepted methods and guidelines for sampling and analysis are an integral part of this monitoring program. Several of the facilities discussed below have state-approved sampling and analysis plans.

The shallow aquifers beneath 5 to 10 percent of the SRS have been contaminated by industrial solvents, metals, tritium, or other constituents used or generated on the Site. Figure 4-12 shows the locations of facilities where the SRS monitors groundwater and areas with constituents that exceeded drinking water standards in 1992; the concentrations shown on Figure 4-12 represent the maximum data from one monitoring well on at least one occasion at a given area. Contamination is limited to the shallow aquifers, with one exception (see next paragraph). Most contaminated groundwater at the SRS is beneath a few facilities; contaminants reflect the operations and chemical processes those facilities perform. For example, contaminants in the groundwater beneath A- and M-Areas include chlorinated volatile organics, radionuclides, metals, and nitrate. At F- and H-Areas, contaminants in the groundwater include tritium and other radionuclides, metals, nitrate, chlorinated volatile organics at values much smaller than those found at A- and M-Areas, and sulfate. The groundwater beneath the Sanitary Landfill contains chlorinated volatile organics, radionuclides, and metals. The groundwater

Table 4-12. Representative groundwater quality data for nonradioactive constituents from the Savannah River Site.

Parameter (Unit)	Standard	Maximum Value
Alkalinity (as CaCO3) (mg/L)	100	1,360[b]
pH (pH units)	8.5[c]	13[b]
Antimony (mg/L)	0.005	0.013
Arsenic (mg/L)	0.05	0.1
Beryllium (mg/L)	0.011[d]	0.0043
Cadmium (mg/L)	0.005[c]	0.34
Chromium (mg/L)	0.1[c]	0.82
Mercury (mg/L)	0.002[c]	0.12
Lead (mg/L)	0.015[e]	1.0
Nitrate-N (mg/L)	10[c]	278[b]
Sulfate (mg/L)	400[c]	73,500[b]
Pentachlorophenol (mg/L)	0.001[c]	0.0032
Lindane (mg/L)	0.0002[c]	0.00048
Carbon tetrachloride (mg/L)	0.005	0.43
1,2-Dichloroethane (mg/L)	0.005[c]	0.27
1,1,1-Trichloroethane (mg/L)	0.2[c]	0.21
1,1-Dichloroethylene (mg/L)	0.007[c]	0.15
Trichlorethylene (mg/L)	0.005[c]	147
Tetrachloroethylene (mg/L)	0.005[c]	101

a. Data compiled from 85 existing wastes sites (Arnett et al. 1993).

b. The elevated values for alkalinity and pH might be due to faulty well installation; the elevated sulfate and nitrate values might be due to acid spills near wells.

c. National secondary drinking water regulations (CFR 1991).

d. National primary drinking water regulations (CFR 1974).

e. Action level at which providers of public drinking water apply treatment technique to reduce lead levels (CFR 1991).

Table 4-13. Representative groundwater data for radioactive constituents from the Savannah River Site (pCi/liter).

Constituent	Standard[b]	Maximum Concentration
Gross alpha	15	2,700
Nonvolatile beta	50	19,000
Tritium	20,000	1.8 x 108
Cesium-137	200	980
Cobalt-60	100	290
Iodine-129	1	72
Ruthenium-106	30	170
Total radium (radium-226 and radium-228)	5	50
Strontium-90	8	5,300

a. Source: Arnett et al. (1993).

b. National Primary Drinking Water Regulations (CFR 1974), (56 FR 33052).

beneath all the reactor areas except R-Area contains tritium, other nuclides, metals, and chlorinated volatile organics. At R-Area, groundwater contaminants include radionuclides and cadmium. The groundwater beneath D-Area contains metals, radionuclides, sulfate, and chlorinated volatile organics. At TNX-Area, the groundwater contains chlorinated volatile organics, radionuclides, and nitrate (Arnett et al. 1993). None of these cases indicated the presence of groundwater contamination beyond Site boundaries. With the ongoing and expanding "pump and treat" system at the A-/M-Area (Figure 4-12), concentrations in the volatile organic compound plume are likely to decrease with time.

Contamination of groundwater in a drinking water aquifer has been found in only one relatively-small area north of A-Area, in the northwest portion of the site. In the early 1980s, SRS monitors found low concentrations of trichloroethylene (11.7 microgram per liter) in water from one production well (53A) completed to the Dublin-Midville Aquifer System (formerly called the Tuscaloosa Formation) in M-Area. The monitors found the contamination only at 430 and 480 feet (131 and 146 meters) in this well, which is 670 feet (204 meters) deep. The well is screened intermittently from 387 feet (118 meters) to the bottom. DOE concluded that the contamination is probably migrating down the outside well casing from soils near the surface that are contaminated with trichloroethylene. This contaminated water enters the well through screens set in the Dublin-Midville System (Du Pont 1983). In addition, in 1992 trichloroethylene and tetrachloroethylene were detected above Primary Drinking Water Standards in cretaceous zone (Dublin-Midville) well MSB 55TA, which is approximately 3,500 feet west of well 53A and 1,500 feet north of A-Area (Arnett et al. 1993).

Figure 4-12. Groundwater contamination at the Savannah River Site.

4.8.2.4 Groundwater Use. The McQueen Branch aquifer, which becomes shallower toward the Fall Line, forms the base for most municipal and industrial water supplies in Aiken County. Toward the coast, in Allendale and Barnwell Counties, this aquifer exists at increasingly greater depths. As a consequence, the shallower Gordon aquifer supplies some municipal, industrial, and agricultural users (Arnett et al. 1993).

DOE has identified 56 major municipal, industrial, and agricultural groundwater users within 20 miles (32 kilometers) of the center of the SRS (DOE 1987a). The total pumpage for these users is about 49 billion liters (13 billion gallons) per year. The SRS withdraws approximately 14.0 billion liters (3.7 billion gallons) of groundwater per year for domestic and industrial uses (DOE 1990).

4.9 Ecological Resources

The U.S. Government acquired the SRS in 1951. At that time, the Site was approximately two-thirds forested and one-third cropland and pasture (Dukes 1984). At present, more than 90 percent of the SRS is forested. An extensive forest management program conducted by the Savannah River Forest Station, which is operated by the U.S. Forest Service, has converted many pastures and croplands to pine plantations. With the exception of the SRS production and support areas, natural succession has reclaimed previously disturbed areas. Table 4-14 lists SRS land cover, other than the land used for nuclear reactors and support facilities.

The SRS is important to maintaining the biodiversity of the region. Satellite imagery of the Site shows a circle of wooded habitat within a matrix of cleared uplands and narrow forested riparian corridors. The SRS provides more than 734 square kilometers (181,000 acres) of contiguous forested cover broken only by unpaved secondary roads, transmission line corridors in various stages of succession, and a few paved primary roads. Carolina bays, the Savannah River swamp, and several relatively intact longleaf pine-wiregrass communities provide important contributions to the biodiversity of the SRS and of the entire region.

Table 4-14. Land cover of undeveloped areas on the Savannah River Site.

Land cover types	Square kilometer	Percent of total
Longleaf pine	150	20
Loblolly pine	258	35
Slash pine	117	16
Mixed pine/hardwood	23	3
Upland hardwood	20	3
Bottomland hardwood	117	16
Savannah River swamp	49	7

Total	734	100.0

a. Source: USDA (1991a).
b. To convert square kilometers to acres, multiply by 247.1.

F- and H-Areas, located near the center of the SRS and approximately 1.6 kilometers (1 mile) southeast of Upper Three Runs Creek, are heavily industrialized with little natural vegetation remaining inside the fenced areas. These areas are dominated by buildings, paved parking lots, gravelled construction areas, and laydown yards. While some grassed areas occur around the administration buildings and some vegetation is present along the ditches that drain the area, the majority of the site contains no vegetation. Wildlife is absent except for occasional crows (Corvus brachyrhynchos) and nesting barn swallows (Hirundo rustica) around the buildings.

Figure 2-3 shows the location of a representative host site at the SRS for potential spent nuclear fuel activities. F- and H-Areas (and developed areas immediately adjacent to them) would house most spent nuclear fuel management facilities, while the undeveloped area south and east of H-Area would be used for the construction of new facilities that F- and H-Areas could not accommodate. The undeveloped area, which was 98 percent cleared fields in 1951, is now almost completely forested, for the most part with 5- to 40-year-old upland pine stands that are actively managed by the Savannah River Forest Station. Most of these stands are loblolly pine (Pinus taeda), but there are small stands of slash pine (P. elliottii), upland hardwoods (predominantly oaks and hickories), and bottomland hardwoods (most commonly sweetgum, Liquidambar styraciflua, and yellow poplar, Liriodendron tulipifera) associated with two small Carolina bays located south of H-Area. The area south of H-Area lies in the Fourmile Branch watershed, while the area east of H-Area is in the McQueen Branch (a tributary of Upper Three Runs Creek) watershed. Neither area is likely to contain any threatened or endangered species or their habitats.

The general area of the representative host site contains suitable habitat for white-tailed deer and feral hogs as well as other faunal species common to the mixed pine/hardwood forests of South Carolina. Additional wildlife species found in the area include gray squirrel (Sciurus carolinensis), fox squirrel (S. niger), wild turkey (Meleagris gallopovo), cottontail rabbit (Sylvilagus floridanus), raccoon (Procyon lotor), bobcat (Felix rufus), and gray fox (Urocyon cinereoargenteus).

4.9.1 Terrestrial Ecology

The SRS is near the transition area between the oak-hickory-pine forest and the southern mixed forest. As a consequence, species typical of both associations occur (Dukes 1984). In addition, farming, fire, soil features, and topography have strongly influenced existing SRS vegetation patterns.

A variety of vascular plant communities occurs in the upland areas (Dukes 1984). Typically, scrub oak communities occur on the drier, sandier areas. Longleaf pine (Pinus palustrus), turkey oak (Quercus laevis), bluejack oak (Q. incana), blackjack oak (Q. marilandica), and dwarf post oak (Q. margaretta) dominate these communities, which typically have understories of wire grass (Aristida stricta) and huckleberry (Vaccinium sp.). Oak-hickory communities occur on more fertile, dry uplands; characteristic species are white oak (Q. alba), post oak (Q. stellata), southern red oak (Q. falcata), mockernut hickory (Carya tomentosa), pignut hickory (C. glabra), and loblolly pine, with an understory of sparkleberry (Vaccinium arboreum), holly (Ilex sp.), greenbriar (Smilax sp.), and poison ivy (Rhus radicans).

The removal of human residents in 1951 and the subsequent restoration of forest cover has provided the wildlife of the SRS with excellent habitat. Furbearers such as gray fox, raccoon, opossum (Didelphis virginiana), bobcat, beaver (Castor canadensis), and otter (Lutra canadensis) are relatively common throughout the Site. Game species such as gray squirrel and fox squirrel, white-tailed deer (Odocoileus virginianus), cottontail rabbit, and wild turkey are also common. The Savannah River Ecology Laboratory has conducted numerous studies of reptile and amphibian use of the wetlands and adjacent uplands of the SRS.

DOE allows carefully regulated public hunting for white-tailed deer and feral hogs (Sus scrofa) on most of the SRS to reduce the incidence of animal/vehicle collisions and maintain healthy populations within the carrying capacity of the range. SRS personnel monitor all animals removed from the Site for contamination before releasing them to the hunters (WSRC 1992a).

Before releasing any animal to a hunter, SRS technicians perform field analyses for cesium-

137 at the hunt site. In 1992, hunters collected 1,519 deer and 168 hogs. The maximum 1992 cesium-137 field measurement for deer was 22.4 picocuries per gram; the average was 6.4 picocuries per gram (Arnett et al. 1993). For hogs, the maximum value was 22.9 picocuries per gram and the average was 3.5 picocuries per gram. The field technicians determine estimated doses from consumption of the venison and pork and make this information available to the hunters.

In 1992, the estimated maximum dose received by a hunter was 49 millirem per year. The basis for this unique hypothetical maximum dose, which was for a hunter who harvested eight deer and one hog, is the assumption that the hunter consumed the entire edible portion of each animal. An additional hypothetical model involved a hunter whose total meat consumption for the year consisted of SRS deer [81 kilograms (179 pounds) per year] (Arnett et al. 1993). Based on these low-probability assumptions and on the average concentration of cesium-137 (6.4 picocuries in deer harvested on the SRS), the estimated potential maximum dose from this pathway is 26 millirem; this is 26 percent of the annual 100-millirem DOE Derived Concentration Guide. Although a large percentage of this hypothetical dose is probably due to cesium-137 from worldwide fallout, the estimated total contains this background cesium-137 for conservatism.

4.9.2 Wetlands

The SRS has extensive, widely distributed wetlands, most of which are associated with floodplains, creeks, and impoundments. In addition, approximately 200 Carolina bays occur on the Site (Shields et al. 1982; Schalles et al. 1989).

The southwestern SRS boundary adjoins the Savannah River for approximately 32 kilometers (20 miles). The river floodplain supports an extensive swamp, covering about 49 square kilometers (12,148 acres) of the Site; a natural levee separates the swamp from the river. Timber was cut in the swamp in the late 1800s. At present, the swamp forest consists of second-growth bald cypress (Taxodium distichum), black gum (Nyssa sylvatica), and other hardwood species (Workman and McLeod 1990; USDA 1991a).

Five major streams drain the SRS and eventually flow into the Savannah River. Each stream has floodplains characterized by bottomland hardwood forests or scrub-shrub wetlands in varying stages of succession. Dominant species include red maple (Acer rubrum), box elder (A. negundo), bald cypress, water tupelo (Nyssa aquatica), sweetgum, and black willow (Salix nigra) (Workman and McLeod 1990).

Carolina bays are unique wetland features of the southeastern United States. They are islands of wetland habitat dispersed throughout the uplands of the SRS. The approximately 200 bays on the Site exhibit extremely variable hydrology and a range of plant communities from herbaceous marsh to forested wetland (Shields et al. 1982; Schalles et al. 1989). SRS scientists have studied Carolina bay ecology extensively, particularly in relation to the construction of the Defense Waste Processing Facility (DWPF; SREL 1980).

4.9.3 Aquatic Ecology

The aquatic resources of the SRS have been the subject of intensive study for more than 30 years. Research has focused on the flora and fauna of the Savannah River and the five tributaries of the river that drain the Site. Section 4.8.1.1 describes those portions of the aquatic systems that spent nuclear fuel management activities could affect. In addition, several monographs (Patrick et al. 1967; Dahlberg and Scott 1971; Bennett and McFarlane 1983), the eight-volume Comprehensive Cooling Water Study (Du Pont 1987), and three EISs (DOE 1984; DOE 1987b; DOE 1990) that evaluated operations of SRS production reactors describe the aquatic biota and aquatic systems of the SRS.

4.9.4 Threatened and Endangered Species

Threatened, Endangered, and Candidate Plant and Animal Species of the Savannah River Site (HNUS 1992b) describes threatened, endangered, and candidate plant and animal species that are known to occur or that might occur on the SRS. Table 4-15 lists these species.

The following Federally listed endangered animals are known to occur on the SRS or in the Savannah River adjacent to the Site: the red-cockaded woodpecker (Picoides borealis), the southern bald eagle (Haliaeetus leucocephalus), the wood stork (Mycteria americana), and the shortnose sturgeon (Acipenser brevirostrum) (HNUS 1992b). Researchers have found one Federally listed endangered plant species, the smooth coneflower (Echinacea laevigata), on the Site, several Federally listed Category 2 species, and several state listed species (Knox and Sharitz 1990). At present, the SRS is implementing strategies for the protection of these species.

Table 4-15. Threatened, endangered, and candidate plant and animal species of the SRS.

Common Name (Scientific Name)	Status
Animals	
Rafinesques (= Southeastern) big-eared bat (Plecotus rafinesquii)	FC2
Loggerhead Shrike (Lanius ludovicianus)	FC2
Bachman's sparrow (Aimophila aestivalis)	FC2
Carolina crawfish (= Gopher) frog (Rana areolata capito)	FC2
Southern hognose snake (Heterodon simus)	FC2
Northern pine snake (Pituophis melanoleucus melanoleucus)	FC2
Bald eagle (Haliaeetus leucocephalus)	E
Wood stork (Mycteria americana)	E
Red-cockaded woodpecker (Picoides borealis)	E
American alligator (Alligator mississippiensis)	T/SA
Shortnose sturgeon (Accipenser brevirostrum)	E
Plants	
Smooth coneflower (Echinacea laevigata)	E
Bog spice bush (Lindera subcoriacea)	FC2
Boykin's lobelia (Lobelia boykinii)	FC2
Loose watermilfoil (Myriophyllum laxum)	FC2
Nestronia (Nestronia umbellula)	FC2
Awned meadowbeauty (Rhexia aristosa)	FC2

Key: E = Federal endangered species.
T/SA = Threatened due to Similarity of Appearance.
FC2 = Under review (a candidate species) for listing by the Federal government.

F- and H-Areas and the representative host site contain no habitat suitable for any of the Federally listed threatened or endangered species found on the SRS. The Southern bald eagle and the wood stork feed and nest near wetlands, streams, and reservoirs, and thus would not be attracted to the host site, a densely forested upland area. Shortnose sturgeon, typically residents of large coastal rivers and estuaries, have never been collected in Fourmile Branch or any of the tributaries of the Savannah River that drain the SRS.

Red-cockaded woodpeckers prefer open pine forests with mature trees (older than 80 years) for foraging and nesting. The pines of the undeveloped host site are 5 to 40 years old, thus red-cockaded woodpeckers probably would not forage or nest in the area.

The Red-cockaded Woodpecker Management Standards and Guidelines, Savannah River Site (USDA 1991b) describes the SRS management strategy for the red-cockaded woodpecker. The most significant element of this management strategy is the conversion of slash (and some loblolly) pine in a designated red-cockaded woodpecker management area to longleaf pine, with a harvest rotation of 120 years.

4.10 Noise

The major noise sources at the SRS occur primarily in developed operational areas and include various facilities, equipment, and machines (e.g., cooling towers, transformers, engines, pumps, boilers, steam vents, paging systems, construction and materials-handling equipment, and vehicles). Major noise sources outside the operational areas consist primarily of vehicles and railroad operations.

Previous studies have assessed noise impacts of existing SRS operational activities (NUS 1991b; DOE 1991b; DOE 1990; DOE 1993a). These studies concluded that, because of the remote locations of the SRS operational areas, there are no known conditions associated with existing onsite noise sources that adversely affect individuals at offsite locations. Some disturbance of wildlife activities might occur on the SRS as a result of operational and construction activities.

Existing SRS-related noise sources of importance to the public are those resulting from the transportation of people and materials to and from the Site. These sources include trucks, private vehicles, helicopters, and freight trains. In addition, a portion of the air cargo and business travel using commercial air transport through the airports at Augusta, Georgia, and Columbia, South Carolina, are attributable to SRS operations.

The States of Georgia and South Carolina and the counties in which the SRS is located have not established any regulations that specify acceptable community noise levels with the exception of Aiken County. A provision of the Aiken County Nuisance Ordinance limits daytime and nighttime noise by frequency band (Aiken County 1991).

During a normal week in 1995, about 20,000 employees are likely to travel to the SRS each day in private vehicles from surrounding communities. Both government-owned and private trucks pick up and deliver materials at the Site. Most private vehicles and trucks traveling to and from the Site each day use South Carolina Highways (SC) 125 and 19. The contribution of SRS operations to traffic volumes along SC 125 and SC 19, especially during peak traffic periods, affects noise levels through the towns of New Ellenton and Jackson and the City of Aiken.

Noise measurements taken during 1989 and 1990 along SC 125 in the Town of Jackson at a point about 15 meters (50 feet) from the roadway indicate that the 1-hour equivalent sound level from traffic ranged from 48 to 72 decibels (A-weighted). The estimated day/night average sound level along this route was 66 decibels for summer and 69 decibels for winter. Similarly, noise measurements along SC 19 in the town of New Ellenton at a point about 15 meters (50 feet) from the roadway indicate that the 1-hour equivalent sound level from traffic ranged from 53 to 71 decibels. The estimated day/night average sound level along this route was 68 decibels for summer and 67 decibels for winter (NUS 1990). Employment at the SRS has increased slightly since 1989, potentially causing small increases in traffic noise, especially during peak traffic periods (approximately between 6:30 and 8:30 a.m. and between 3:30 and 5:30 p.m., corresponding to the major shift changes). Because some residences and at least two schools are within 100 to 200 feet of these routes, some annoyance to members of the public residing along these highways might occur based on the relationship between the day/night average sound level and the "percent highly annoyed" (Schultz 1978; Fidell et al. 1989; FICON 1992).

Noise sources from rail transport include diesel engines, wheel-track contact, and whistle-warnings at rail crossings.

4.11 Traffic and Transportation

4.11.1 Regional Infrastructure

The SRS is surrounded by a system of Interstate highways, U.S. highways, state highways, and railroads. The regional transportation networks service the four South Carolina counties (Aiken, Allendale, Bamberg, and Barnwell) and two Georgia counties (Columbia and Richmond) that generate about 90 percent of SRS commuter traffic (HNUS 1992a). Two major railroads - CSX Transportation and Norfolk Southern Corporation - also serve the SRS vicinity. Although barge traffic is possible on the Savannah River, neither the SRS nor commercial shippers normally use barges. Figure 4-13 shows the regional transportation infrastructure.

4.11.1.1 Regional Roads. Two Interstate highways serve the SRS area. Interstate 20 (I-20)

provides a primary east-west corridor and I-520 links I-20 with parts of Augusta, Georgia. U.S. Highways 1 and 25 are principal north-south routes and U.S. 78 provides east-west connections. Several other highways - U.S. 221, U.S. 301, U.S. 321, and U.S. 601 - provide additional transport routes in the region.

Several state routes provide direct access to the SRS. Running northwest/southeast is SC 125. Access to the Site is provided from the north by SC 19, from the northeast by SC 39, and from the east by SC 64.

U.S. 278 bisects the northern part of the SRS and is available to public access without restriction. The SRS maintains barricades at site entries and exits on SC 125 to control public access if necessary, although it is generally open to unrestricted public travel. The public also has direct access to Site Road 1. All other site roads have restricted access.

4.11.1.2 Regional Railroads. Norfolk Southern serves Augusta and Savannah, Georgia, as

well as Columbia and Charleston, South Carolina. CSX serves the same locations and the SRS.

4.11.2 SRS Infrastructure

The SRS transportation infrastructure consists of more than 143 miles (230 kilometers) of primary roads, 1,200 miles (1,931 kilometers) of unpaved secondary roads, and 103 kilometers (64 miles) of railroad track (WSRC 1993b). These roads and railroads provide connections among the various SRS facilities and to offsite transportation linkages. Figure 4-14 shows the SRS network of primary roadways and access points. Figure 4-15 shows the SRS railway system.

4.11.2.1 SRS Roads. Two major public highways traverse the Site: SC 125 and U.S. 278.

SC 125 connects Allendale, South Carolina, to Augusta, Georgia, by crossing the Site in a northwest-to-southeast direction. U.S. 278 also connects Augusta and Allendale, but its route approximately follows the northern and eastern SRS boundaries.

Figure 4-13. Regional transportation infrastructure. Figure 4-14. Major SRS road and access points. Figure 4-15. SRS railroads lines.

Ten barricades around the Site limit access from public roads. Five barricades limit SRS access from SC 125; three limit access from SC 19, SC 39, and SC 64; and two limit access from the public areas of the administrative complex near the northern SRS boundary (A-Area).

In general, the primary SRS roadways are in good condition and are smooth and free from potholes. Typically, wide, firm shoulders border roads that are either straight or have wide gradual turns. Intersections are well marked for both traffic and safety identification and are sufficiently cleared of trees and brush that might obstruct a driver's view of oncoming traffic. Railings along the side of the roadways offer protection at appropriate locations from dropoffs or other hazards. In general, the roadways are lighted only at gate areas and near major facilities. The SRS has two overpasses, one at the cloverleaf intersection of Roads 2 and C, and the other where SC 125 overpasses the CSX railroad tracks in the southern part of the Site. The 60 bridges on the Site have been inspected and evaluated for safe loading, with some bridges rated as high as 200 tons (181 metric tons) under controlled conditions. The steepest roadway gradient is on Road C at the east bank of Upper Three Runs Creek, where the road drops more than 100 feet (30 meters) in about 0.25 miles (0.4 kilometer). At the base of the dropoff is a bridge over the creek and an immediate turn in the road. This area presents a relatively hazardous roadway condition.

In general, heavy traffic occurs early in the morning and late in the afternoon when workers from surrounding communities commute to and from the Site. During working hours, official vehicles and logging trucks constitute most of the traffic. At any time, as many as 60 logging trucks, which can impede traffic, might be operating on the Site, with an annual average of about 25 trucks per day. Table 4-16 provides data on traffic counts for various roads and access points around the SRS.

4.11.2.2 SRS Railroads. Railroads on the Site include both CSX tracks and SRS rolling

stock and tracks. Two routes of the CSX distribution system run through the Site: a line between Florence, South Carolina, and Augusta, Georgia, and a line between Yemassee, South Carolina, and Augusta, Georgia. The two lines join on the Site just south of L-Lake (Figure 4-15). Early in 1989

CSX discontinued service on the line from the SRS junction to Florence.

The 64 miles (103 kilometers) of SRS railroads are well maintained. The rails and crossties are in good condition, and the track lines are clear of vegetation and debris. Significant clear areas border the tracks on both sides. Intersections of railroads and roadways are marked by railroad crossing signs with lights where appropriate.

Table 4-16. SRS traffic counts - major roads.

Measurement point	Date	Direction	Day Total	Peak[b]	Peak time[c]	Average speed (mph)[d]
Road 2 between Roads C and D	2-23-93	East	3,031	800	1530	47
	4-21-93	West	3,075	864	0630	NA[e]
Road 4 between Roads E and C	12-9-92	East	1,624	352	1530	NA
	12-9-92	West	1,553	306	0615	NA
Road 8 at Pond C	2-23-92	East	634	274	1530	58
	2-23-92	West	662	331	0615	56
Road C between landfill and R	12-16-92	North	6,931	2,435	1530	53
	12-16-92	South	6,873	2,701	0630	58
Road C north of Road 7	1-20-93	North	742	288	0630	53
	1-20-93	South	763	223	1530	54
Road D	9-29-93	North	1,779	218	1500	43
	9-29-93	South	1,813	220	0845	52
Road E at E-Area	8-25-93	North	3,099	669	1530	35
	8-25-93	South	3,054	804	0630	38
Road F at Upper Three Runs Cr	2-2-93	North	3,239	1,438	1530	53
	2-2-93	South	3,192	1,483	0630	51
H-Area Exit	12-2-92	Outbound	2,181	406	1530	12

a. Source: Swygert (1993).
b. Number of vehicles in peak hour.
c. Start of peak hour.
d. mph = miles per hour; to convert to kilometers per hour multiply by 1.6093.
e. NA = data not available.

The SRS rail classification yard is east of P-Reactor. This eight-track facility sorts and redirects rail cars. Deliveries of SRS shipments occur at two onsite rail stations at the former towns of Ellenton and Dunbarton. From these stations, an SRS engine moves the railcars to the appropriate receiving facility. The Ellenton station, which is on the main Augusta-Yemassee line, is the preferred delivery point. The Dunbarton station, which is on the discontinued portion of the Augusta-Florence line, receives less use.

4.12 Occupational and Public Radiological Health and Safety

The sources of radiation exposure to individuals consist of natural background radiation from cosmic, terrestrial, and internal body sources; radiation from medical diagnostic and therapeutic practices; and radiation from manmade sources, including consumer and industrial products, nuclear facilities, and weapons test fallout.

All radiation doses discussed in this document are effective dose equivalents (i.e., organ dose equivalents weighted for biological effect and summed to yield a whole-body dose equivalent with the same risk as irradiation of individual organs) as defined by the International Commission on Radiological Protection, Publication 26 (ICRP 1977), unless specifically identified otherwise (e.g., thyroid dose, bone dose).

Natural background radiation contributes about 83 percent of the annual dose of 380 millirem received by an average member of the population within 50 miles (80 kilometers) of the Site. Based on national averages, medical exposure accounts for 14 percent of the annual dose, and the combined doses from weapons test fallout, consumer and industrial products, and air travel account for approximately 3 percent (Arnett et al. 1993).

4.12.1 Occupational Health and Safety

SRS maintains a network of air monitoring stations on and around the Site to determine the concentrations of radioactive particulates and aerosols in the air (Arnett et al. 1993). Table

4-17 lists average and maximum radionuclide particulate concentrations found in 1992 in air at the F- and H-Areas, SRS boundary, and background [100-mile (160-kilometer) radius] monitoring locations. Table 4-18 lists average and maximum concentrations of tritium in atmospheric moisture during 1992 for the F- and H-Areas, SRS boundary, and background monitoring locations.

Gamma radiation levels measured by thermoluminescent dosimeters in 1992 at the F- and H-Area **fences averaged 70 and 74 millirem per year, respectively.** Gamma radiation levels, including natural background (terrestrial and cosmic) radiation, measured at the Site perimeter in 1992 yielded an average dose of 35 millirem per year (Arnett et al. 1993).

Table 4-17. Radioactivity in air at the Savannah River Site and vicinity (pCi/m3).

Location	Gross Alpha	Nonvolatile Beta	SR-89,90b	Pu-238b	Pu-239b
F-Area					
Average	1.80x10-3	1.94x10-2	0.62x10-4	1.26x10-5	8.15x10-6
Maximum	3.55x10-3	5.56x10-2	6.02x10-4	2.64x10-5	2.48x10-5
H-Area					
Average	1.80x10-3	1.93x10-2	2.69x10-4	2.03x10-5	5.14x10-6
Maximum	4.24x10-3	5.39x10-2	2.83x10-3	6.03x10-5	1.41x10-5
Site perimeter					
Average	1.80x10-3	2.30x10-2	0.13x10-4	0.01x10-7	2.40x10-7
Maximum	4.04x10-2	4.95x10-2	4.54x10-4	2.21x10-6	2.76x10-6
Background (100-mile radius)					
Average	1.67x10-3	1.73x10-2	0.49x10-4	0.72x10-6	<1.00x10-6
Maximum	3.83x10-3	4.37x10-2	6.89x10-4	1.98x10-5	6.15x10-6

a. Arnett et al. (1993).
b. Monthly composite.

Table 4-18. Tritium measured in air at the Savannah River Site (pCi/cc).

Location	Average	Maximum
F-Area	8.67x10-5	2.98x10-4
H-Area	0.99x10-3	6.77x10-3
Site boundary	2.65x10-5	1.03x10-4
Background (100-mile radiu	8.32x10-6	1.08x10-5

a. Arnett (1993).

Soil samples from uncultivated areas provide a measure of the quantity of particulate radioactivity deposited from the atmosphere. Table 4-19 lists maximum measurements of radionuclides in the soil for 1992 at F- and H-Areas, SRS boundary, and background [100-mile (160-kilometer)-radius] monitoring locations. The SRS measured elevated concentrations of plutonium-238 and plutonium-239 around F- and H-Areas, reflecting releases from these areas. From 1955 through 1992, total atmospheric plutonium releases from the F- and H-Areas were approximately 0.7 curie of plutonium-238 and 3 curies of plutonium-239 (Arnett et al. 1992; 1993).

Table 4-19. Maximum radioactivity concentrations in soil at the Savannah River Site (pCi/g).

Location	Sr-90	Cs-137	Pu-238	Pu-239
F-Area	2.16x10-2	7.19x10-1	4.03x10-1	5.31x10-1
H-Area	2.89x10-2	8.22x10-1	2.13x10-2	5.54x10-2
Site perimeter	(b)	4.84x10-1	2.19x10-3	1.36x10-2
Background (100-mile radius)	1.46x10-2	(b)	2.34x10-4	1.93x10-2

a. Arnett et al. (1992).
b. None detected.

The SRS workers investigated for purposes of assessing occupational radiation exposures belong to the group of involved workers assigned to F- and H-Area facilities. The investigation selected these facilities because they process materials with radiological characteristics similar to the materials being analyzed in this EIS. The dosimetry results for these two involved worker groups are most useful because they depict occupational impacts that are directly relevant to each alternative. The investigation selected two dosimetry periods of record for this analysis: 1983 - 1987 and 1993. The earlier 5-year period included times when materials processing was occurring at a rate that was accelerated in comparison with recent years. The later period includes processing rates that better reflect near-term DOE mission initiatives.

Tables 4-20 and 4-21 list the involved worker dosimetry data for 1983 - 1987 and 1993, respectively. This analysis adapted these data from monitoring data statistics (Matheny 1994a; Matheny 1994b) for operations, maintenance, laboratory, and health protection personnel assigned to the F- and H-Area Canyons and the associated B-Line facilities. The calculated incidences of excess fatal cancer attributable to each facility's collective worker dose are approximately 0.11 and 0.037 for the earlier and later time periods, respectively. Similarly, the highest calculated excess fatal cancer probabilities attributable to average individual worker doses are approximately 0.0003 and 0.0001, respectively. The analysis estimated these health effects using risk coefficients adopted by DOE (DOE 1993).

4.12.2 Public Health and Safety

Table 4-22 summarizes the major sources of exposure for the population within 50 miles (80 kilometers) of the SRS and for the Savannah River water-consuming population in Beaufort and Jasper Counties, South Carolina, and Port Wentworth, Georgia. Most of the sources, such as natural background dose and medical dose, are independent of the presence of the SRS.

Table 4-20. Annual involved worker doses, 1983 - 1987.

Facility	Average Worker Dose (rem)	Total Collective Worker Dose (person-rem)
H-Canyon	0.41	36.28
HB-Line	0.49	21.84
F-Canyon	0.48	87.25
FB-Line	0.74	124.68
Facilities Average	0.53	NA
Facilities Total	NA	270.05

NA = Not applicable.

Table 4-21. Annual involved worker doses, 1993.

Facility	Average Worker Dose (rem)	Total Collective Worker Dose (person-rem)
H-Canyon	0.17	11.07
HB-Line	0.24	21.97
F-Canyon	0.22	9.16
FB-Line	0.24	51.16
Facilities Average	0.22	NA
Facilities Total	NA	93.36

NA = Not applicable.

Table 4-22. Major sources of radiation exposure to the public in the vicinity of the Savannah River Site.

Source of Exposure	Dose to average individual (mrem/yr)	Percentage of exposure
Natural background radiation	315	83
Medical radiation	54	14
Consumer and industrial products, fallout, air travel	10	3
Savannah River Site operations	0.22	0.06
Grand Total	380	100

a. Arnett et al. (1993).

Atmospheric releases of radioactive material to the environment from SRS operations from 1990 to 1992 resulted in an average dose of approximately 0.02 millirem per year to individuals in the 50-mile (80-kilometer)-radius population. The collective effective dose equivalent due to atmospheric releases from 1992 SRS operations to the population of 620,100 within 50 miles (80 kilometers) was approximately 6.4 person-rem per year. Atmospheric releases of tritium accounted for more than 90 percent of the offsite population dose; tritium is the only radionuclide of SRS origin that is routinely detected in offsite air (Cummins et al. 1991; Arnett et al. 1992, 1993). Table 4-23 lists average annual atmospheric tritium concentrations in the vicinity of SRS for the three years ending in 1992.

Table 4-23. Average atmospheric tritium concentrations in the vicinity of the Savannah River Site (pCi/m3).

Location	1992	1991	1990
Onsite	340	250	430
Site perimeter	27	21	32
25-mile radius	11	11	12
100-mile radius	8.3	8.5	8.8

a. Arnett et al. (1993).

From 1990 to 1992, the calculated maximum individual average annual dose from atmospheric releases to a hypothetical individual residing at the SRS boundary was 0.12 millirem (Cummins et al. 1991; Arnett et al. 1992, 1993).

In general, liquid releases of tritium account for more than 99 percent of the total radioactivity introduced into the Savannah River from SRS activities (Arnett et al. 1993). The calculated average annual dose to the maximally exposed individual resulting from liquid releases from 1990 to 1992 was 0.21 millirem (Cummins et al. 1991; Arnett et al. 1992; 1993). From 1990 to 1992 liquid releases of radioactive material to the environment from SRS operations resulted in an average dose of 0.04 millirem per year and 0.05 millirem per year to downstream consumers of drinking water from the Beaufort-Jasper and Port Wentworth water treatment plants, respectively. These doses to the current Beaufort-Jasper river-water-consuming population of about 51,000 and the current Port Wentworth river-water-consuming population of about 20,000 would yield a collective effective dose equivalent to these populations of approximately 3 person-rem per year (Cummins et al. 1991; Arnett et al. 1992, 1993).

The SRS analyzes samples from other environmental media that onsite releases might affect and that might provide a pathway for radiation exposure to the public and Site employees; these include samples of milk, food products, drinking water, wildlife, rainwater, soil, sediment, and vegetation. The 1992 SRS Environmental Report (Arnett et al. 1993) describes the sampling program, monitoring locations, and monitoring results for each of these media.

Major nuclear facilities within 50 miles (80 kilometers) of the SRS include a low-level waste burial site operated by Chem-Nuclear Systems, Inc., near the eastern SRS boundary in Barnwell, South Carolina, and the Georgia Power Company Alvin W. Vogtle Electric Generating Plant, directly across the Savannah River from the SRS. Plant Vogtle began commercial operation in 1987, and its releases are controlled to meet U.S. Nuclear Regulatory Commission requirements.

4.13 Utilities and Energy

This section describes SRS electricity consumption, water consumption, fuel usage, and domestic and industrial wastewater treatment. Table 4-24 contains information on the current status of these items at SRS.

Table 4-24. Current capacities and usage of utilities and energy at SRS.

ELECTRICITY	
Consumption	659,000 megawatt hours per year
Load	75 megavolt-amperes
Peak Demand	130 megavolt-amperes
Capacity	340 megavolt-amperes
WATER	
Groundwater usage	12,490 million liters (3.3 billion gallons) per year
Surface water usage (cooling)	75,700 million liters (20 billion gallons) per year
FUEL	
Oil	28.4 million liters (7.5 million gallons) per year
Coal	210,000 metric tons (230,000 tons) per year
Gasoline	4.7 million liters (1.24 million gallons) per year
WASTEWATER	
Domestic capacity	3.97 million liters (1.05 million gallons) per day
Domestic load	1.89 million liters (0.50 million gallons) per day
Industrial capacity[a,b]	1.64 million liters (433,244 gallons) per day
Industrial load[a]	44,000 liters (11,580 gallons) per day

a. F/H Effluent Treatment Facility only.
b. Design capacity; permitted capacity is about 67 percent of this value.

4.13.1 Electricity

The SRS purchases electric power from the South Carolina Electric and Gas Company (SCE&G) through three purchased power-line interconnects to the SRS transmission grid. The recent total annual power consumption for the SRS was approximately 659,000 megawatt-hours. The average load was 75 megavolt-amperes and the peak demand was about 130 megavolt-amperes. South Carolina Electric and Gas sources can supply as much as 340 megavolt-amperes to the SRS grid with existing direct connections. The SRS generating station in D-Area can produce an additional 80 megavolt-amperes capacity, although that plant currently produces only process steam. The SRS transmission grid that would provide power to any spent nuclear fuel facilities consists of more than 145 kilometers (90 miles) of 115-kilovolt lines, four switching stations, and 15 substations. Electric service to all major production areas provides parallel redundant capacity to ensure maximum availability and reliability (WSRC 1993c).

4.13.2 Water Consumption

Groundwater from a deep confined aquifer supplies domestic and process water for the SRS through approximately 100 production wells. The aquifer system sustains single well yields of about 10.2 million liters (2.7 million gallons) per day. Current usage from this source is about 14.0 billion liters (3.7 billion gallons) per year (DOE 1990). The SRS withdraws cooling water for its facilities from the Savannah River at an annual rate of about 75.7 billion liters (20 billion gallons) (WSRC 1993c).

4.13.3 Fuel Consumption

Fuels consumed at SRS include oil, coal, and gasoline. SRS facilities and equipment burn approximately 28.4 million liters (7.5 million gallons) of oil each year. This total includes diesel fuel, No. 6 oil, and No. 2 oil. The SRS burns coal and some waste oils in the D-Area powerhouse to produce steam for Site facilities. Current coal usage is about 208,655 metric tons (230,000 tons) per year. SRS vehicles use approximately 4.7 million liters (1.24 million gallons) of gasoline annually. Under the provisions of the Energy Policy Act of 1992, natural gas will replace gasoline on the SRS within the next 10 years. At that time, SRS usage of natural gas would be approximately 12.2 million cubic meters (429 million cubic feet) per year. At present, the SRS consumes no natural gas (WSRC 1993c).

4.13.4 Wastewater Treatment

By 1995, the SRS Centralized Sanitary Wastewater Treatment Facility will process most of the domestic effluent on the Site. This centrally located facility has a design capacity of 4 million liters (1.05 million gallons) per day. Once operational, the plant will use about 50 percent of this capacity. In addition, five smaller sanitary treatment plants serve more remote areas of the Site. Facilities for spent nuclear fuel management would use the centralized facility.

The F/H Effluent Treatment Facility (ETF), which decontaminates routine process effluents and accidental radioactive releases from operations, treats industrial wastewater in the F- and H-Areas, where the spent fuel management activities would occur.

Effluent Treatment Facility process operations performed on the waste liquids include neutralization (adjusts pH), submicron filtration (removes suspended solids), activated carbon absorption (removes dissolved organic chemicals), reverse osmosis membrane deionization (removes salts), ion exchange (removes heavy metals), and evaporation (separates radionuclides from aqueous condensate). This facility releases two different streams. The treated water stream is sampled and analyzed to ensure that it meets discharge requirements and then is released to Upper Three Runs Creek via a permitted outfall. The waste concentrate (i.e., bottoms from the evaporator process) is transferred to the H-Area waste tank farm for treatment and disposal in the Z-Area Saltstone facility.

The design capacity for the Effluent Treatment Facility is approximately 600 million liters (158 million gallons) per year. The maximum permitted treatment capacity is about 400 million liters (105.7 million gallons) per year. Under normal operating conditions, the facility treats more than 16,000 cubic meters (26 million gallons) of liquid waste per year (WSRC 1993d).

The influent water load to processes discharging to the permitted outfall includes as much as 205 million liters (54 million gallons) per year of F-Area Canyon process wastewater, 120 million liters (32 million gallons) per year of H-Area Canyon process wastewater, 34 million liters (9 million gallons) per year from the F-Area collection and retention basins, 34 million liters (9 million gallons) per year from the H-Area collection and retention basins, 68 million liters (18 million gallons) per year of Effluent Treatment Facility acid, caustic, flush and rinse water, and similar wastewater from other SRS facilities.

4.14 Materials and Waste Management

The historic national defense mission of the SRS has resulted in the generation of high-level radioactive waste, transuranic waste, low-level radioactive waste (low-activity and intermediate-level), hazardous waste, mixed waste (radioactive and hazardous combined), and sanitary waste (nonhazardous, nonradioactive solid waste). This section discusses the treatment, storage, and disposal of waste at the SRS. Section 4.13 discusses domestic and industrial wastewater treatment.

DOE is preparing an environmental impact statement on Waste Management at the Savannah River Site (DOE 1995). The purpose of the EIS is to provide a basis for DOE to select a sitewide strategic approach to managing present and future SRS waste generated as a result of ongoing operations, environmental restoration activities, transition from nuclear production to other missions, and decontamination and decommissioning programs. The Waste Management EIS will support project-level decisions on the operation of specific treatment, storage, and disposal facilities within the near term (10 years or less). In addition, the EIS will provide a baseline for analyses of future waste management activities and a basis for the evaluation of the specific waste management alternatives. The Waste Management EIS will not include management of spent nuclear fuel which is addressed in this document.

DOE treats and stores waste generated from onsite operations in waste management facilities located primarily in E-, F-, H-, N-, S-, and Z-Areas (Figure 4-16). These facilities include the F- and H-Area Effluent Treatment Facility, the High-Level Waste Tank Farms, and the Solid Waste Disposal Facility. The Defense Waste Processing Facility is nearly operational and the Consolidated Incineration Facility is under construction. The SRS places sanitary and inert waste in the Interim Sanitary Landfill and the Burma Road Landfill, respectively.

DOE continues to reduce the amount of waste generated and disposed of at the SRS through waste minimization and treatment programs. DOE accomplishes waste minimization by reducing the volume, toxicity, or mobility of waste before storing or disposing of it. These activities also include more intensive surveying, waste segregation, and use of administrative and engineering controls.

The waste that DOE presently stores on the SRS includes high-level, transuranic, hazardous, mixed waste and some low-level waste. The Site stores high-level waste in underground storage tanks that have received South Carolina Department of Health and Environmental Control industrial wastewater permits, and manages them in accordance with Clean Water Act, Resource Conservation and Recovery Act, and DOE requirements. The SRS stores transuranic mixed waste on interim-status storage pads in accordance with South Carolina Department of Health and Environmental Control requirements and DOE Orders. Hazardous and mixed waste is placed in permitted or interim-status storage in the Hazardous Waste Storage Facilities (both buildings and pads) and in the mixed waste storage buildings.

Figure 4-16. Waste management facilities at the Savannah River Site.

Figure 4-17 shows the high-level liquid waste management process at the SRS. Figure 4-18 shows the process for handling all other forms of solid waste at the Site.

Table 4-25 is a forecast of annual waste generation for all waste forms except sanitary and high-level waste (WSRC 1994c). The volumes listed do not include waste related to decontamination and decommissioning because DOE has not yet completed the planning of these activities. Section 5.14 discusses potential consequences of spent nuclear fuel activities as they relate to the alternative interim storage and treatment scenarios.

4.14.1 High-Level Waste

The SRS generated high-level waste from the recovery of nuclear materials from spent fuel and target processing in the F- and H-Areas. It is stored in 50 underground tanks. These tanks also store other radioactive waste effluents (primarily low-level radioactive waste such as aqueous process waste, including purge water from storage basins for irradiated reactor fuel or fuel elements). The high-level waste is stored to permit the decay of short-lived radionuclides and allow separation of solids (sludge) from soluble waste. Evaporators concentrate soluble waste to reduce original volumes and to immobilize it as crystallized salt by successive evaporations of the liquid supernate. The SRS treats the evaporator overheads in cesium removal columns before transferring them to the F- and H-Area Effluent Treatment Facility. The SRS processes the sludge and salt to prepare them for vitrification at the Defense Waste Processing Facility (high-level waste), when it becomes operational, or stabilization at the Z-Area Saltstone Facility (low-level waste). DOE has prepared a Supplemental EIS related to Defense Waste Processing Facility operations (DOE 1994d).

By December 31, 1991, DOE had stored approximately 127.9 million liters (33.8 million gallons) of high-level radioactive waste on the Site. Estimates of current tank capacity and high-level waste forecasts should be available in 1995. In general, however, due to a number of factors, the most important of which has been the extended outage of the evaporators, the estimated inventory of waste in the high-level tanks is greater than 90 percent of existing capacity (WSRC 1994d). DOE is constructing a replacement high-level waste tank evaporator to augment or replace existing evaporators.

Figure 4-17. Flow diagram for high-level radioactive waste. Figure 4-18. Flow diagram for waste handling at the SRS.

Table 4-25. Average annual waste generation forecast for Savannah River Site (cubic meters). ,b

Waste Type	FY94	FY95	FY96
Transuranic	670	860	760
Low-Level			
Low-Activity	21,350	17,680	17,970
Intermediate-Level	940	580	740
Hazardous	140	130	100
Mixed	120	130	110

a. Source: WSRC (1994c).
b. To convert cubic meters to cubic feet, multiply by 35.314.

4.14.2 Transuranic Waste

At present, DOE uses three methods of retrievable storage for transuranic waste at SRS, based on the time of generation. Transuranic waste generated before 1974 is buried in approximately 120 belowgrade concrete culverts in the Solid Waste Disposal Facility. Transuranic waste generated from 1974 to 1985 is stored on five concrete pads and one asphalt pad that have been covered with approximately 1.2 meters (4 feet) of native soil. DOE stores waste generated since 1985 on 13 additional concrete pads that are not covered with soil. Pads 1 through 17 operate under Interim Status approved by the South Carolina Department of Health and Environmental Control. DOE uses Pads 18 through 19, which are not required to have interim status, to manage nonhazardous transuranic wastes only.

The SRS stores wastes containing 10 to 100 nanocuries per gram of transuranic material with transuranic waste until it can complete Site-specific radiological performance assessments, which will provide disposal limits for transuranic isotopes. SRS transuranic waste inventories and forecasts include both transuranic waste and the 10- to 100-nanocuries-per-gram transuranic wastes.

At the end of 1993, the SRS had approximately 9,900 cubic meters (350,000 cubic feet) of transuranic waste in storage (WSRC 1994e). Based on the 1994-to-1996 average annual generation rate forecast, the Site generates approximately 760 cubic meters (27,000 cubic feet) of transuranic waste annually. Transuranic mixed waste (transuranic and hazardous combined) accounts for approximately 110 cubic meters (3,900 cubic feet) of this volume (WSRC 1994c). DOE is evaluating available storage space for transuranic mixed waste to alleviate any storage capacity deficit.

4.14.3 Mixed Low-Level Waste

The SRS mixed waste program consists primarily of providing safe storage until treatment and disposal facilities are available. The current volume of mixed low-level waste at the SRS is 1,700 cubic meters (60,000 cubic feet) (WSRC 1994e). Based on the 1994-to-1996 average annual generation forecast, the Site generates approximately 118 cubic meters (4,170 cubic feet) of mixed low-level waste annually (WSRC 1994c). DOE is evaluating available storage space to determine when the SRS will exceed its capacity. However, DOE is constructing a Consolidated Incineration Facility in H-Area, which will treat mixed, hazardous, and low-level waste. When the incinerator is operational, existing inventory will be reduced and more storage capacity will become available.

4.14.4 Low-Level Waste

The SRS packages low-level waste for disposal on the Site in accordance with the waste category and its estimated surface dose rate. The Site places low-activity waste in carbon steel boxes and deposits it in an Engineered Low-Level Trench (ELLT). The trenches are several acres in size by 6 meters (20 feet) deep and have sloped sides and floor, allowing drainage to a collection sump. When the trenches are full, DOE backfills and covers them with at least 1.8 meters (6 feet) of soil. The Site packages intermediate-level wastes according to the waste form and disposes of them in slit trenches. DOE will store long-lived wastes, such as resins, until the Long-Lived Waste Storage Building, currently under construction, becomes operational. This building will provide storage until DOE develops treatment and disposal technologies.

The SRS is developing a new disposal facility, known as the E-Area Vault (EAV). This facility will include vaults for low-activity waste, intermediate-level non-tritium waste, and intermediate-level tritium waste.

Based on the 1994-to-1996 average annual generation forecast, the Site generates approximately 19,000 cubic meters (671,400 cubic feet) of low-activity waste and 750 cubic meters (26,600 cubic feet) of intermediate-level waste annually. DOE expects that the Consolidated Incineration Facility will begin operations by the second quarter of Fiscal Year 1996; this facility will have the capability of annually processing as much as 15,850 cubic meters (560,000 cubic feet) of boxed low-activity waste and approximately 186 cubic meters (6,600 cubic feet) of hazardous and mixed waste.

4.14.5 Hazardous Waste

DOE stores hazardous wastes generated at various SRS facilities in buildings in the B- and N-Areas, and on the Solid Waste Storage Pads. The Resource Conservation and Recovery Act regulates these wastes.

The inventory of hazardous waste in storage at the SRS is about 1.6 million kilograms (3.6 million pounds), occupying a volume of about 2,430 cubic meters (86,000 cubic feet) (WSRC 1994e). Based on the 1994-to-1996 average annual generation rate forecast, the Site generates approximately 124 cubic meters (4,370 cubic feet) of hazardous waste annually (WSRC 1994c).

4.14.6 Sanitary Waste

The SRS disposes of most of its solid sanitary waste in onsite landfills, the most recent of which began operation in 1985. Current disposal operations include the Interim Sanitary Landfill. About 30 trucks per work day arrive at this facility carrying approximately 18,125 kilograms (40,000 pounds) of waste that, after compaction, occupies approximately 115 cubic meters (150 cubic yards) of landfill space. The recent implementation of SRS paper and aluminum can recycling programs and disposal of office waste off the Site in a commercial landfill has increased the projected life of the landfill to the fourth quarter of 1996 (WSRC 1994e).

DOE also maintains an inert material landfill on the Site near Burma Road. This facility receives demolition and construction debris. DOE is evaluating the construction of a new SRS sanitary landfill or the use of a commercial landfill.

4.14.7 Hazardous Materials

The SRS 1993 Tier II emergency and hazardous chemical inventory lists 205 reportable hazardous substances present on the Site in excess of the 10,000-pound (4,536-kilogram) threshold quantity (WSRC 1994f). The number and the total weight of any hazardous chemicals used on the Site change daily in response to use. The annual Superfund Amendments and Reauthorization Act (SARA) reports for the SRS include listings of hazardous materials used or stored on the Site during each year.

5. ENVIRONMENTAL CONSEQUENCES

5.1 Overview

This chapter discusses the potential environmental consequences for each spent nuclear fuel management alternative described in Chapter 3. The representative host site locations, as described in Chapter 2, are the F- and H-Areas and an undeveloped site close to H-Area. These sites are representative of available areas that could support spent fuel management missions. Based on generic facility characteristics, this chapter analyzes representative consequences in terms of the environmental attributes of the potential host areas and the Savannah River Site (SRS) at large, as described in Chapter 4. Table 3-2 compares the environmental consequences of each alternative. The impacts associated with the construction and operation of a Navy Expended Core Facility are not included in this chapter, but are included in Appendix D of Volume 1 of this Environmental Impact Statement.

5.2 Land Use

Overall environmental impacts on land use by any of the alternatives would be small because the U.S. Department of Energy (DOE) would construct most new facilities in F- and H-Areas, which are already dedicated to industrial use and which previous activities have disturbed. New construction on the undeveloped representative host site near H-Area would probably be necessary only for the construction of a dry storage vault.

The Centralization Alternative (Alternative 5), under which DOE would transfer all spent nuclear fuel to the SRS, would result in the greatest changes in land use. Under this alternative, the SRS would dedicate between 70 and 100 acres (0.3 and 0.4 square kilometer) for use in spent nuclear fuel management; the exact location and size of the area affected would depend on whether DOE chose to use the wet storage, dry storage, or processing option. Of this affected area, a maximum of approximately 100 acres (0.4 square kilometer) would change from managed pine forest to industrial use.

DOE would retain under its control any lands supporting the spent nuclear fuel management program for the life of the project. No alternative would require the acquisition of public lands.

5.3 Socioeconomics

Socioeconomic consequences resulting from the implementation of any of the alternatives would relate primarily to changes in employment within the region of influence (ROI). DOE has based the analysis in the following section on estimated employment and population data for each SRS spent nuclear fuel alternative, as listed in Table 5-1. The population within the region of influence in 1995 is estimated to be approximately 462,000. The labor force will be about 257,000 persons of which about 242,000 will be employed.

DOE expects the employment level at the Site to decline from about 20,000 (in 1995) to about

15,800 (in 2004) as the SRS mission is redefined. This anticipated decline would be somewhat offset by the jobs created by the spent nuclear fuel management activities. Therefore, none of the alternatives would require additional operations employees because the SRS could fill all operational positions through the reassignment of existing workers. Consequently, this analysis addresses only employment impacts from construction activities. Given the natural variation in construction employment levels, the analysis could not accurately determine the reassignment of existing construction workers. As a result, this assessment analyzed the maximum potential impact, which assumes that all construction employment would represent new jobs that in-migrating workers would fill.

DOE estimated total employment impacts using the Regional Input-Output Modeling System that the U.S. Bureau of Economic Analysis developed for the SRS region of influence. This assessment also analyzed changes in population based on historic data that indicate that 90 percent of SRS employees live in the six-county region.

5.3.1 Potential Impacts

Table 5-1 lists direct increases in construction employment for each alternative and the corresponding change in population. As listed, potential impacts to socioeconomic resources would be smallest under Alternative 1 (No Action) and would be greatest under Option 5b (Centralization - Wet Storage). Therefore, Option 5b provides the bounding case for maximum potential impacts to socioeconomic resources.

Table 5-1. Direct construction employment and total population changes by alternative, 1995-2004.

Alternative	1995a	1996a	1997a	1998a	1999a	2000	2001	2002	2003	2004
Alternative 1- Employmenta	50	50	50	50	50	50	50	50	50	50
Population	200	150	150	100	100	100	100	100	100	100
Option 2a- Employment	50	50	50	50	50	200	400	600	500	200
Population	200	150	150	100	100	850	1,550	2,250	2,000	750
Option 2b- Employment	50	50	50	50	50	200	400	600	500	200
Population	100	150	150	100	100	850	1,550	2,250	2,000	750
Option 2c- Employment	50	50	50	50	50	200	350	550	500	150
Population	200	150	150	100	100	700	1,350	2,050	1,850	600
Option 3a- Employment	50	50	50	50	50	200	400	600	500	200
Population	200	150	150	100	100	850	1,550	2,250	2,000	750
Option 3b- Employment	50	50	50	50	50	200	400	650	600	250
Population	200	150	150	100	100	800	1,600	2,550	2,400	900
Option 3c- Employment	50	50	50	50	50	200	350	550	500	150
Population	200	150	150	100	100	700	1,350	2,050	1,850	600
Option 4a- Employment	50	50	50	50	50	200	400	650	600	250
Population	200	150	150	100	100	800	1,600	2,550	2,400	900
Option 4b- Employment	50	50	50	50	50	200	400	650	600	250
Population	200	150	150	100	100	800	1,600	2,550	2,400	900
Option 4c-	50	50	50	50	50	200	350	550	500	

Employment										150
Population	200	150	150	100	100	700	1,350	2,050	1,850	600
Option 4d-Employment	50	50	50	50	50	300	500	700	650	250
Population	200	200	150	150	150	1,100	1,900	2,800	2,500	900
Option 4e-Employment	50	50	50	50	50	250	500	800	800	300
Population	200	200	150	150	150	1,000	2,000	3,200	3,000	1,100
Option 4f-Employment	50	50	50	50	50	200	450	650	600	200
Population	200	200	150	150	150	850	1,700	2,550	2,350	700
Option 4g-Employment	50	50	50	50	50	100	150	200	100	100
Population	200	150	150	100	100	250	500	700	450	300

Alternative	1995a	1996a	1997a	1998a	1999a	2000	2001	2002	2003	2004
Option 5a-Employment	50	50	50	50	50	900	1,750	2,550	2,500	2,450
Population	200	150	150	100	100	3,500	6,800	9,900	9,700	9,450
Option 5b-Employment	50	50	50	50	50	1,000	1,900	2,700	2,650	2,600
Population	200	150	150	100	100	3,850	7,450	10,550	10,350	10,100
Option 5c-Employment	50	50	50	50	50	900	1,750	2,550	2,500	2,450
Population	200	150	150	100	100	3,500	6,800	9,900	9,700	9,500
Option 5d-Employment	50	50	50	50	50	100	150	200	100	100
Population	200	150	150	100	100	250	500	700	450	300

a. Construction is related to renovation of reactor basin and Receiving Basin for Offsite Fuels.

Table 5-2 lists indirect employment and corresponding population changes associated with construction phase activities under Option 5b. As listed, the number of full-time construction workers required to support the implementation of this option from 1995 to 2004 would range from approximately 50 to 2,700. When added to the indirect employment of 1,600 jobs in the peak year (2002), the total employment impact in the region would be approximately 4,300 employees.

Table 5-2. Estimated increases in employment and population related to construction activities for Option 5b, from 1995 to 2004. ROI refers to the six-county region of influence.

Factor	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Direct employment	50	50	50	50	50	1,000	1,900	2,700	2,650	2,600
Secondary employment	30	30	30	30	30	600	1,100	1,600	1,550	1,500
Total employment change	80	80	80	80	80	1,600	3,000	4,300	4,200	4,100
% Change in ROI labor force	0.03	0.03	0.03	0.03	0.03	0.54	1.00	1.41	1.36	1.32
% Change in ROI employment	0.03	0.03	0.03	0.03	0.03	0.57	1.06	1.50	1.45	1.40
Population change (in region)	200	150	150	100	100	3,850	7,450	10,550	10,350	10,100
% Change in ROI population	0.04	0.03	0.03	0.02	0.02	0.81	1.56	2.21	2.16	2.11

Assuming in-migrating workers filled all jobs, the regional labor force and employment would increase by 1.4 percent and 1.5 percent, respectively. These changes would be temporary and would have no adverse impact on the region. After 2004, employment would gradually decline to a relatively constant level of about 50 jobs.

Based on historic data, approximately 90 percent of new employees would live within the six-county region of influence. Assuming each new employee represented one household with 2.72 persons per household, there would be approximately 10,550 additional people in the region during the peak year (2002). These changes would be temporary and would represent an estimated 2.2 percent increase in baseline population levels. Given this minor change in population, DOE expects potential impacts on the demand for community resources and services such as housing, schools, police, health care, and fire protection to be negligible.

Because all the other alternatives would require fewer employees, they would result in smaller changes than those listed in Table 5-2, and would have no adverse impacts on socioeconomic resources in the region of influence.

5.4 Cultural Resources

A Programmatic Memorandum of Agreement (SRARP 1989) between the DOE Savannah River Operations Office, the South Carolina State Historic Preservation Office, and the Advisory Council on Historic Preservation, ratified on August 24, 1990, is the instrument for the management of cultural resources at the SRS. DOE uses this memorandum to identify cultural resources, assess them in terms of eligibility for the National Register of Historic Places, and develop mitigation plans for affected resources in consultation with the State Historic Preservation Officer. DOE would comply with the terms of the memorandum for all activities needed to support spent nuclear fuel management actions.

The potential for adverse impacts on cultural resources would be smallest under Alternative 1 (No Action) and would be greatest under Alternative 5 (Centralization). Any facilities that DOE would construct in F- and H-Areas, north of Road E (Alternatives 1-5), would be in Sensitivity Zones 2 and 3. Section 4.4 describes these zones. The undeveloped representative host site south and east of H-Area (Alternative 5) is in Sensitivity Zone 3. Although there are no known archeological sites in the area, it has never been surveyed. Surveying being conducted near F-Area (north of Road C and west of Road 4 along Upper Three Runs Creek) has recorded some historic and prehistoric sites. However, DOE expects no impacts in F- and H-Areas due to their extensive industrial development. Until DOE has determined the precise locations of facilities connected with any of the alternatives, it cannot predict impacts on cultural resources in the undeveloped site area (Sassaman 1994). However, DOE would mitigate, through avoidance or removal, impacts to potentially significant resources that future site surveys might discover.

5.5 Aesthetic and Scenic Resources

None of the alternatives for spent nuclear fuel management at the SRS would have adverse consequences on scenic resources or aesthetics. Most new construction would be in F- or H-Area, both of which are already dedicated to industrial use. New construction on the undeveloped site, which would occur primarily under Alternative 5, would be adjacent to H-Area in an already heavily industrialized portion of the SRS. In all cases, new construction would not be visible off the Site or from public access roads on the Site. No alternative would produce emissions to the atmosphere that would be visible or would indirectly reduce visibility.

5.6 Geologic Resources

The SRS contains no unique geologic features or minerals of economic value. Therefore, DOE anticipates no impacts to geologic resources at the SRS from any of the spent nuclear fuel management alternatives.

Other sections in this chapter consider the relationships of the Site's specific geology and the region's historic and analyzed seismicity to the local environment and to SRS spent nuclear fuel-related structures and facilities. Section 5.8 discusses the consequences of analyzed seismic events on both surface-water and groundwater resources. Section 5.15 describes estimates of risk that consider both the probability of and the consequences from a wide range of seismic events, ranging from local and regional historically documented earthquakes to postulated lower probability, higher consequence events.

The accident analyses in this chapter, which DOE based on information from approved safety analysis reports for applicable facilities, address the frequency and consequences of historic earthquakes, as well as postulated less likely, but more damaging, seismic events. DOE has evaluated the consequences from seismic challenges to the facilities and structures up to 0.20g lateral ground acceleration.

5.7 Air Quality Consequences

The SRS is in compliance with both Federal and state ambient air quality standards for criteria and toxic air pollutants. As shown in the following tables, the predicted incremental air pollutant impacts would not contribute to exceeding either the National Ambient Air Quality Standards or South Carolina's Ambient Air Quality Standards.

DOE performed analyses using computer models in order to assess the potential air quality impacts of operations under each of the spent nuclear fuel management alternatives. This section describes the results of these analyses. All the concentrations discussed below are ground-level estimations based on results from the ISC2 and FDM models for nonradiological pollutants, and MAXIGASP- and POPGASP SRS-climatology-specific models for radionuclides. The analyses assume that facility operations would result in both radiological and nonradiological emissions. DOE assessed construction impacts qualitatively in relation to the land area to be disturbed under each alternative.

Nonradiological Emissions. DOE analyzed the potential incremental impacts of only those substances for which it expects releases to the atmosphere during the normal operation of spent nuclear fuel facilities. The nonradiological releases evaluated for each alternative include seven criteria pollutants and 23 toxic pollutants. DOE selected the toxic substances for analysis by comparing the anticipated chemical usage at the proposed spent nuclear fuel facilities to the list of 257 toxic air pollutants in the South Carolina Air Pollution Regulations (SCDHEC 1976). The SRS modeled potential emissions of the listed toxic chemicals that DOE anticipates would be used during spent nuclear fuel activities. The following subsections discuss the results for both criteria and toxic pollutants. Tables 5-3 and 5-4 list the estimated maximum incremental concentrations of these pollutants at the Site boundary, while Tables 5-5 and 5-6 contain the incremental rates of release.

Radiological Emissions. DOE evaluated the potential radiological releases to the atmosphere from spent fuel management at the SRS using existing Site historical operations information. Based on the actual 1993 emissions data from the Receiving Basin for Offsite Fuels (WSRC 1994d), DOE estimates that emissions from any of the wet storage options under Alternatives 1 through 4 would

Table 5-3. Estimated incremental air quality impacts at the Savannah River Site boundary from operations of spent nuclear fuel alternatives - criteria pollutants (-g/m3).

Incremental Concentrations from Alternatives

Pollutantb	Averaging Time	Regulatory Standardc	Maximum Potential Concentration	Actual Concentratione	No Action	Decentralization			1992/1993 Planning Basis		
					1	2a	2b	2c	3a	3b	3c
CRITERIA POLLUTANTS (-g/m3)											
Carbon monoxide	8-hour	10,000	818	23	<0.01	0.1	0.1	4.3	0.1	0.1	4.3
	1-hour	40,000	3,553	180	<0.01	0.8	0.8	32	0.8	0.8	32
Ozone (as VOC)	1-hour	245	N/Ad	N/Ad	1.6	0.3	0.3	2.6	0.3	0.3	2.6

Nitrogen oxides	Annual geometric mean	100	30	4	<0.01	0.01	<0.01	11.00	<0.01	<0.01	11.0
Particulate matter (<10-m)	Annual	50	9	3	-	-	-	<0.01	-	-	0.01
	24-hour	150	93	56	-	-	-	0.40	-	-	0.40
Total suspended particulates (TSP)	Annual	75	20	11	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sulfur dioxide	Annual	80	18	10	-	<0.01	<0.01	0.01	<0.01	<0.01	0.01
	24-hour	365	356	185	-	0.01	0.01	0.43	0.01	0.01	0.43
	3-hour	1,300	1,210	634	-	0.05	0.05	3.2	0.05	0.05	3.2
Lead	Calendar quarter mean	1.5	<0.01	<0.01	-	-	-	-	-	-	-
Gaseous Fluorides (as HF)	1-month	0.8	0.11	0.03	-	-	-	0.02	-	-	0.02
	1-week	1.6	0.6	0.15	-	-	-	0.10	-	-	0.10
	24-hour	2.9	1.20	0.31	-	-	-	0.20	-	-	0.20
	12-hour	3.7	2.40	0.62	-	-	-	0.40	-	-	0.40

Table 5-3. (continued).

Incremental Concentrations from Alternatives

Pollutantb	Averaging Time	Regulatory Standardc	Maximum Potential Concentration	Actual Concentratione							
						Regionalization A			Regionalization B		
					4a	4b	4c	4d	4e	4f	4g
CRITERIA POLLUTANTS (-g/m3)											
Carbon monoxide	8-hour	10,000	818	23	0.2	0.2	4.3	0.2	0.2	5.5	-
	1-hour	40,000	3,553	180	1.2	1.2	32	1.5	1.5	41	-
Ozone (as VOC)	1-hour	245	N/Ad	N/Ad	0.5	0.5	2.6	0.6	0.6	3.3	1.4
Nitrogen oxides	Annual geometric mean	100	30	4	<0.01	<0.01	11	<0.01	<0.01	14	-
Particulate matter (<10-m)	Annual	50	9	3	-	-	0.01	-	-	0.01	-
	24-hour	150	93	56	-	-	0.4	-	-	0.5	-
Total suspended particulates (TSP)	Annual	75	20	11	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Sulfur dioxide	Annual	80	18	10	<0.01	<0.01	0.01	<0.01	<0.01	0.01	-
	24-hour	365	356	185	0.02	0.02	0.43	0.02	0.02	0.55	-
	3-hour	1,300	1,210	634	0.09	0.09	3.2	0.11	0.11	4.1	-
Lead	Calendar quarter mean	1.5	<0.01	<0.01	-	-	-	-	-	-	-
Gaseous Fluorides (as HF)	1-month	0.8	0.11	0.03	-	-	0.02	-	-	0.02	-
	1-week	1.6	0.6	0.15	-	-	0.10	-	-	0.13	-
	24-hour	2.9	1.20	0.31	-	-	0.20	-	-	0.25	-
	12-hour	3.7	2.40	0.62	-	-	0.40	-	-	0.51	-

Table 5-3. (continued).

Incremental Concentrations from Alternatives

Pollutant	Averaging Time	Regulatory Standard[c]	Maximum Potential Concentration	Actual Concentration[e]	Centralization 5a	5b	5c	5d
CRITERIA POLLUTANTS (-g/m3)								
Carbon monoxide	8-hour	10,000	818	23	1.0	1.0	5.1	-
	1-hour	40,000	3,553	180	6.7	6.7	37	-
Ozone (as VOC)	1-hour	245	N/A[d]	N/A[d]	1.4	1.4	3.1	1.4
Nitrogen oxides	Annual geometric mean	100	30	4	0.04	0.04	11.1	-
Particulate matter (<10-m)	Annual	50	9	3	-	-	0.01	-
	24-hour	150	93	56	-	-	0.40	-
Total suspended particulates (TSP)	Annual	75	20	11	<0.01	<0.01	<0.01	-
Sulfur dioxide	Annual	80	18	10	<0.01	<0.01	0.02	-
	24-hour	365	356	185	0.09	0.09	0.49	-
	3-hour	1,300	1,210	634	0.50	0.50	3.5	-
Lead	Calendar quarter mean	1.5	<0.01	<0.01	-	-	-	-
Gaseous Fluorides (as HF)	1-month	0.8	0.11	0.03	-	-	0.02	-
	1-week	1.6	0.6	0.15	-	-	0.10	-
	24-hour	2.9	1.20	0.31	-	-	0.10	-
	12-hour	3.7	2.40	0.62	-	-	0.40	-

- = No impact.

a. Maximum modeled ground-level concentration at SRS perimeter unless higher offsite concentrations are otherwise specified.

b. Major pollutants of concern regarding spent nuclear fuel management activities.

c. Most stringent Federal and state regulatory standards (CFR 1991a), (SCDHEC 1976).

d. Measurement data currently unavailable.

e. Maximum operational air pollutant emissions projected for baseline year 1995. Concentration estimates based on actual emissions from all SRS sources for calendar year 1990 plus maximum potential emissions for sources permitted through December 1992.

Table 5-4. Estimated incremental air quality impacts at the Savannah River Site boundary from operations of spent nuclear fuel alternatives - toxic pollutants (-g/m3).

Pollutant[b]	Averaging Time	Regulatory Standard[c]	Maximum Potential Concentration	Actual Concentration[d]	Incremental Concentrations from Alternatives: No Action 1	2a	Decentralization 2b	2c	1992/1993 Planning Basis 3a	3b	3c
TOXIC POLLUTANTS (-g/m3)											
Nitric acid	24-hour	125	51	6.7	-	-	-	<0.01	-	-	<0.01
1,1,1,- Trichloroethane	24-hour	9,550	81	22	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.01
Benzene	24-hour	150	32	31	-	-	-	0.04	-	-	0.04
Ethanolamine	24-hour	200	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ethyl benzene	24-hour	4,350	0.58	0.12	-	-	-	<0.01	-	-	<0.01
Ethylene glycol	24-hour	650	0.20	0.08	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Formaldehyde	24-hour	7.5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Glycol ethers	24-hour	+	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Hexachloronapthalene	24-hour	1.0	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Hexane	24-hour	200	0.21	0.07	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	0.04
Manganese	24-hour	25	0.82	0.10	-	-	-	<0.01	-	-	<0.01
Methyl alcohol	24-hour	1,310	2.9	0.51	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Methyl ethyl ketone	24-hour	14,750	6.0	0.99	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Methyl isobutyl ketone	24-hour	2,050	3.0	0.51	-	-	-	<0.01	-	-	<0.01
Methylene chloride	24-hour	515	10.5	1.8	-	-	-	0.02	-	-	0.02
Naphthalene	24-hour	1,250	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenol	24-hour	190	0.03	0.03	-	-	-	<0.01	-	-	<0.01
Phosphorus	24-hour	0.5	<0.001	<0.001	-	-	-	<0.001	-	-	<0.001
Sodium hydroxide	24-hour	20	0.01	0.01	-	-	-	<0.01	-	-	<0.01
Toluene	24-hour	2,000	9.3	1.6	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	0.04
Trichloroethylene	24-hour	6,750	4.8	1.0	-	-	-	<0.01	-	-	<0.01
Vinyl acetate	24-hour	176	0.06	0.02	-	-	-	<0.01	-	-	<0.01
Xylene	24-hour	4,350	39	3.8	0.01	0.01	0.01	0.05	0.01	0.01	0.05

Table 5-4. (continued).

Pollutantb	Averaging Time	Regulatory Standardc	Maximum Potential Concentration	Actual Concentrationd	Incremental Concentrations from Alternatives						
					Regionalization A					Regionalization B	
					4a	4b	4c	4d	4e	4f	4g
TOXIC POLLUTANTS (-g/m3)											
Nitric acid	24-hour	125	51	6.7	-	-	1.0	-	-	1.3	-
1,1,1,- Trichloroethane	24-hour	9,550	81	22	<0.01	<0.01	0.01	<0.01	<0.01	0.01	<0.01
Benzene	24-hour	150	32	31	-	-	0.04	-	-	0.05	-
Ethanolamine	24-hour	200	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ethyl benzene	24-hour	4,350	0.58	0.12	-	-	<0.01	-	-	<0.01	-
Ethylene glycol	24-hour	650	0.20	0.08	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Formaldehyde	24-hour	7.5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Glycol ethers	24-hour	+	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Hexachloronapthalene	24-hour	1.0	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Hexane	24-hour	200	0.21	0.07	<0.01	<0.01	0.04	<0.01	<0.01	0.05	<0.01
Manganese	24-hour	25	0.82	0.10	-	-	<0.01	-	-	<0.01	-
Methyl alcohol	24-hour	1,310	2.9	0.51	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Methyl ethyl ketone	24-hour	14,750	6.0	0.99	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Methyl isobutyl ketone	24-hour	2,050	3.0	0.51	-	-	<0.01	-	-	<0.01	-
Methylene chloride	24-hour	515	10.5	1.8	-	-	0.02	-	-	0.02	-
Naphthalene	24-hour	1,250	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenol	24-hour	190	0.03	0.03	-	-	<0.01	-	-	<0.01	-
Phosphorus	24-hour	0.5	<0.001	<0.001	-	-	<0.001	-	-	<0.001	-
Sodium hydroxide	24-hour	20	0.01	0.01	-	-	<0.01	-	-	<0.01	-
Toluene	24-hour	2,000	9.3	1.6	<0.01	<0.01	0.04	<0.01	<0.01	<0.05	<0.01

Trichloroethylene	24-hour	6,750	4.8	1.0	-	-	<0.01	-	-	<0.01	-
Vinyl acetate	24-hour	176	0.06	0.02	-	-	<0.01	-	-	<0.01	-
Xylene	24-hour	4,350	39	3.8	0.01	0.01	0.05	0.01	0.01	0.06	0.01

Table 5-4. (continued).

Pollutantb	Averaging Time	Regulatory Standardc	Maximum Potential Concentration	Actual Concentrationd	Incremental Concentrations from Alternatives Centralization			
					5a	5b	5c	5d
TOXIC POLLUTANTS (-g/m3)								
Nitric acid	24-hour	125	51	6.7	-	-	1.0	-
1,1,1,- Trichloroethane	24-hour	9,550	81	22	<0.01	<0.01	0.01	<0.01
Benzene	24-hour	150	32	31	-	-	0.04	-
Ethanolamine	24-hour	200	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ethyl benzene	24-hour	4,350	0.58	0.12	-	-	<0.01	-
Ethylene glycol	24-hour	650	0.20	0.08	<0.01	<0.01	<0.01	<0.01
Formaldehyde	24-hour	7.5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Glycol ethers	24-hour	+	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Hexachloronapthalene	24-hour	1.0	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Hexane	24-hour	200	0.21	0.07	<0.01	<0.01	0.04	<0.01
Manganese	24-hour	25	0.82	0.10	-	-	<0.01	-
Methyl alcohol	24-hour	1,310	2.9	0.51	<0.01	<0.01	<0.01	<0.01
Methyl ethyl ketone	24-hour	14,750	6.0	0.99	<0.01	<0.01	<0.01	<0.01
Methyl isobutyl ketone	24-hour	2,050	3.0	0.51	-	-	<0.01	-
Methylene chloride	24-hour	515	10.5	1.8	-	-	0.02	-
Naphthalene	24-hour	1,250	0.01	0.01	<0.01	<0.01	<0.01	<0.01
Phenol	24-hour	190	0.03	0.03	-	-	<0.01	-
Phosphorus	24-hour	0.5	<0.001	<0.001	-	-	<0.001	-
Sodium hydroxide	24-hour	20	0.01	0.01	-	-	<0.01	-
Toluene	24-hour	2,000	9.3	1.6	<0.01	<0.01	0.04	<0.01
Trichloroethylene	24-hour	6,750	4.8	1.0	-	-	<0.01	-
Vinyl acetate	24-hour	176	0.06	0.02	-	-	<0.01	-
Xylene	24-hour	4,350	39	3.8	0.01	0.01	0.05	0.01

- No impact.
+ Not available.

a. Maximum modeled ground-level concentration at SRS perimeter unless higher offsite concentrations are otherwise specified.
b. Major pollutants of concern regarding spent nuclear fuel.
c. Most stringent Federal and state regulatory standards (CFR 1991a), (SCDHEC 1976).
d. Maximum operational air pollutant emissions projected for baseline year 1995. Concentration estimates based on actual emissions from all SRS sources for calendar year 1990 plus maximum potential emissions for sources permitted through December 1992.

Table 5-5. Incremental air quality pollutant emission rates related to spent nuclear fuel alternatives - criteria pollutants.

Pollutant	Baseline	Alternatives
	Maximum Design	No Action

	1992/1993 Planning Basis			Decentralization					
	Capacity	Actualb	1	2a	2b	2c	3a	3b	3c
CRITERIA POLLUTANTS (TONS PER YEAR)									
NOx	2.22x104	2.62x103	-	6.0x100	6.0x100	2.0x104	6.0x100	6.0x100	2.0x104
Particulates									
TSP	3.62x103	9.80x102	-	4.0x10-1	4.0x10-1	1.5x101	4.0x10-1	4.0x10-1	1.5x101
PM10	2.66x103	4.97x102	-	2.6x10-1	2.6x10-1	9.3x100	2.6x10-1	2.6x10-1	9.3x100
CO	6.77x103	1.99x102	-	1.5x100	1.5x100	3.8x101	1.5x100	1.5x100	3.8x101
SO2	6.42x104	6.68x103	1.6x10-3	4.0x10-1	4.0x10-1	1.2x101	4.0x10-1	4.0x10-1	1.2x101
Gaseous Fluorides	2.14x10-2	1.07x10-2	-	-	-	2.4x101	-	-	2.4x101
Ozone (as VOC)	N/Ac	N/Ac	-	6.0x10-1	6.0x10-1	1.8x10-1	6.0x10-1	6.0x10-1	1.8x10-1

CRITERIA POLLUTANTS (TONS PER YEAR)			Regionalization A		Regionalization B				
			4a	4b	4c	4d	4e	4f	4g
NOx	2.22x104	2.62x103	8.5x100	8.5x100	2.0x104	1.1x101	1.1x101	2.5x104	-
Particulates									
TSP	3.62x103	9.80x102	6.0x10-2	6.0x10-2	1.5x101	7.6x10-2	7.6x10-2	1.5x101	-
PM10	2.66x103	4.97x102	1.45x101	1.45x101	9.3x100	1.8x101	1.8x101	9.3x100	-
CO	6.77x103	1.99x102	2.0x100	2.0x100	3.8x101	2.5x100	2.5x100	5.2x101	-
SO2	6.42x104	6.68x103	5.5x10-2	5.5x10-2	1.3x101	7.6x10-2	7.6x10-2	1.7x101	-
Gaseous Fluorides	2.14x10-2	1.07x10-2	-	-	2.4x101	-	-	3.0x101	-
Ozone (as VOC)	N/Ac	N/Ac	8.5x10-1	8.5x10-1	1.8x10-1	1.1x100	1.1x100	2.3x10-1	-

Table 5-5. (continued).

Pollutant	Maximum Design Capacity	Actualb	Alternatives			
			Centralization			
CRITERIA POLLUTANTS (TONS PER YEAR)			5a	5b	5c	5d
NOx	2.2x104	2.6x103	5.6x101	5.6x101	2.0x104	-
Particulates						
TSP	3.62x103	9.8x102	2.1x100	2.1x100	1.8x101	-
PM10	2.66x103	4.97x102	1.4x100	1.4x100	9.3x100	-
CO	6.77x103	1.99x102	2.7x101	2.7x101	6.9x101	-
SO2	6.42x104	6.68x103	8.1x100	8.1x100	2.0x101	-
Gaseous Fluorides	2.14x10-2	1.07x10-2			2.4x101	-
Ozone (as VOC)	N/Ac	N/Ac	4.6x100	4.6x100	2.4x101	-

a. Source: WSRC (1994a).

b. Maximum operational air pollutant emissions projected for baseline year 1995. Concentration estimates based on actual emissions from all SRS sources for calendar year 1990 plus maximum potential emissions for sources permitted through December 1992.

c. Emissions data currently unavailable.

- No proposed incremental emissions.

Table 5-6. Incremental air quality pollutant emission rates related to spent nuclear fuel alternatives - toxic pollutants.

Pollutant	Baseline		Alternatives						
	Maximum Design		No Action	Decentralization					
1992/1993 Planning Basis	Capacity	Actualb	1	2a	2b	2c	3a	3b	3c

TOXIC POLLUTANTS (TONS PER YEAR)									
Nitric Acid	1.13x103	2.56x100	5.1x10-2	5.1x10-2	5.1x10-2	1.24x102	5.1x10-2	5.1x10-2	1.24x102
1,1,1-Trichloroethane	8.0x101	NAc	-	-	-	7.02x10-1	-	-	7.02x10-1
Benzene	2.9x101	4.48x100	-	-	-	8.02x10-1	-	-	8.02x10-1
Ethanolamine	2.21x10-2	5.35x10-3	1.46x10-3	1.46x10-3	1.46x10-3	1.46x10-3	1.46x10-3	1.46x10-3	1.46x10-3
Ethyl Benzene	2.56x100	1.07x100	-	-	-	8.02x10-4	-	-	8.02x10-4
Ethylene Glycol	6.83x10-1	4.17x10-1	2.25x10-2	2.25x10-2	2.25x10-2	4.27x10-2	2.25x10-2	2.25x10-2	4.27x10-2
Formaldehyde	4.55x10-2	4.8x10-4	3.6x10-6	3.6x10-6	3.6x10-6	3.6x10-6	3.6x10-6	3.6x10-6	3.6x10-6
Glycol Ethers	4.36x10-3	1.99x10-4	4.06x10-3	4.06x10-3	4.06x10-3	4.06x10-3	4.06x10-3	4.06x10-3	4.06x10-3
Hexachloronaphthalene	<0.01	NAc	3.65x10-5	3.65x10-5	3.65x10-5	3.6x10-5	3.65x10-5	3.65x10-5	3.6x10-5
Hexane	3.54x100	2.22x10-1	3.28x10-3	3.28x10-3	3.28x10-3	8.13x10-1	3.28x10-3	3.28x10-3	8.13x10-1
Manganese	2.84x10-1	3.43x10-1	-	-	-	1.51x10-2	-	-	1.51x10-2
Methyl Alcohol	6.62x10-1	3.46x10-1	6.84x10-2	6.84x10-2	6.84x10-2	8.68x10-2	6.84x10-2	6.84x10-2	8.68x10-2
Methyl Ethyl Ketone	6.41x100	3.17x100	2.19x10-3	2.19x10-3	2.19x10-3	3.47x10-2	2.19x10-3	2.19x10-3	3.47x10-2
Methyl Isobutyl Ketone	8.25x100	2.25x100	-	-	-	1.27x10-2	-	-	1.27x10-2
Methylene Chloride	1.53x100	1.19x100	-	-	-	8.23x10-1	-	-	8.23x10-1
Naphthalene	7.22x10-2	3.08x10-2	5.84x10-4	5.84x10-4	5.84x10-4	6.08x10-4	5.84x10-4	5.84x10-4	6.08x10-4
Phenol	8.07x10-2	1.37x10-2	-	-	-	6.01x10-5	-	-	6.01x10-5
Phosphorus	2.97x10-3	1.65x10-4	-	-	-	1.6x10-6	-	-	1.6x10-6
Sodium Hydroxide	1.26x10-1	1.26x10-1	-	-	-	5.97x10-2	-	-	5.97x10-2
Toluene	3.91x100	7.66x10-1	5.0x10-2	5.0x10-2	5.0x10-2	9.2x10-1	5.0x10-2	5.0x10-2	9.2x10-1
Trichloroethylene	2.52x101	9.8x100	-	-	-	5.52x10-4	-	-	5.52x10-4
Vinyl Acetate	4.38x10-2	5.9x10-3	-	-	-	5.0x10-5	-	-	5.0x10-5
Xylene	1.46x103	1.22x101	1.58x10-1	1.58x10-1	1.58x10-1	1.4x100	1.58x10-1	1.58x10-1	1.4x100

Table 5-6. (continued).

	Baseline		Alternatives						
Pollutant	Maximum Design Capacity	Actualb	Regionalization A				Regionalization B		
			4a	4b	4c	4d	4e	4f	4g
TOXIC POLLUTANTS (TONS PER YEAR)									
Nitric Acid	1.1x103	2.6x100	5.1x10-2	5.1x10-2	1.2x102	6.5x10-2	6.5x10-2	1.5x102	-
1,1,1-Trichloroethane	8.0x101	NAc	-	-	7.0x10-1	-	-	8.9x10-1	-
Benzene	2.9x101	4.5x100	-	-	8.0x10-1	-	-	1.0x100	-
Ethanolamine	2.2x10-2	5.4x10-3	1.5x10-3	1.5x10-3	1.5x10-3	1.9x10-3	1.9x10-3	1.9x10-3	-
Ethyl Benzene	2.6x100	1.1x100	-	-	8.0x10-4	-	-	1.0x10-3	-
Ethylene Glycol	6.8x10-1	4.2x10-1	2.3x10-2	2.3x10-2	4.3x10-2	2.9x10-2	2.9x10-2	5.5x10-2	-
Formaldehyde	4.6x10-2	4.8x10-4	3.6x10-6	3.6x10-6	3.6x10-5	4.6x10-6	4.6x10-6	4.6x10-6	-
Glycol Ethers	4.4x10-3	2.0x10-4	4.1x10-3	4.1x10-3	4.1x10-3	5.2x10-3	5.2x10-3	5.2x10-3	-
Hexachloronapthalene	<0.01	NAc	3.7x10-5	3.7x10-5	3.6x10-5	4.7x10-5	4.7x10-5	4.6x10-5	-
Hexane	3.5x100	2.2x10-1	3.3x10-3	3.3x10-3	8.1x10-1	4.2x10-3	4.2x10-3	1.0x100	-

Manganese	2.8x10-1	3.4x10-1	-	-	1.5x10-2	-	-	1.9x10-2	-
Methyl Alcohol	6.6x10-1	3.5x10-1	6.8x10-2	6.8x10-2	8.7x10-2	8.6x10-2	8.6x10-2	1.1x10-1	-
Methyl Ethyl Ketone	6.4x100	3.2x100	2.2x10-3	2.2x10-3	3.5x10-2	2.8x10-3	2.8x10-3	4.4x10-2	-
Methyl Isobutyl Ketone	8.3x100	2.3x100	-	-	1.3x10-2	-	-	1.7x10-2	-
Methylene Chloride	1.5x100	1.2x100	-	-	8.2x10-1	-	-	1.0x100	-
Naphthalene	7.2x10-2	3.1x10-2	5.8x10-4	5.8x10-4	6.1x10-4	7.4x10-4	7.4x10-4	7.7x10-4	-
Phenol	8.1x10-2	1.4x10-2	-	-	6.0x10-5	-	-	7.6x10-5	-
Phosphorus	3.0x10-3	1.7x10-4	-	-	1.6x10-6	-	-	2.0x10-6	-
Sodium Hydroxide	1.3x10-1	1.3x10-1	-	-	6.0x10-2	-	-	7.6x10-2	-
Toluene	3.9x100	7.7x10-1	5.0x10-2	5.0x10-2	9.2x10-1	6.4x10-2	6.4x10-2	1.2x100	-
Trichloroethylene	2.5x101	9.8x100	-	-	5.5x10-4	-	-	7.0x10-4	-
Vinyl Acetate	4.4x10-2	5.9x10-3	-	-	5.0x10-5	-	-	6.4x10-5	-
Xylene	1.5x103	1.2x101	1.6x10-1	1.6x10-1	1.4x100	2.0x10-1	2.0x10-1	1.8x100	-

Table 5-6. (continued).

Pollutant	Maximum Design Capacity	Actual[b]	Alternatives			
			Centralization			
			5a	5b	5c	5d
TOXIC POLLUTANTS (TONS PER YEAR)						
Nitric Acid	1.1x103	2.6x100	5.1x10-2	5.1x10-2	1.2x102	-
1,1,1-Trichloroethane	8.0x101	NA[c]	-	-	7.0x10-1	-
Benzene	2.9x101	4.5x100	-	-	8.0x10-1	-
Ethanolamine	2.2x10-2	5.4x10-3	1.5x10-3	1.5x10-3	1.5x10-3	-
Ethyl Benzene	2.6x100	1.1x100	-	-	8.0x10-4	-
Ethylene Glycol	6.8x10-1	4.2x10-1	2.3x10-2	2.3x10-2	4.3x10-2	-
Formaldehyde	4.6x10-2	4.8x10-4	3.6x10-6	3.6x10-6	3.6x10-6	-
Glycol Ethers	4.4x10-3	2.0x10-4	4.1x10-3	4.1x10-3	4.1x10-3	-
Hexachloronapthalene	<0.01	NA[c]	3.7x10-5	3.7x10-5	3.6x10-5	-
Hexane	3.5x100	2.2x10-1	3.3x10-3	3.3x10-3	8.1x10-1	-
Manganese	2.8x10-1	3.4x10-1	-	-	1.5x10-2	-
Methyl Alcohol	6.6x10-1	3.5x10-1	6.8x10-2	6.8x10-2	8.7x10-2	-
Methyl Ethyl Ketone	6.4x100	3.2x100	2.2x10-3	2.2x10-3	3.5x10-2	-
Methyl Isobutyl Ketone	8.3x100	2.3x100	-	-	1.3x10-2	-
Methylene Chloride	1.5x100	1.2x100	-	-	8.2x10-1	-
Naphthalene	7.2x10-2	3.1x10-2	5.8x10-4	5.8x10-4	6.1x10-4	-
Phenol	8.1x10-2	1.4x10-2	-	-	6.0x10-5	-
Phosphorus	3.0x10-3	1.7x10-4	-	-	1.6x10-6	-
Sodium Hydroxide	1.3x10-1	1.3x10-1	-	-	6.0x10-2	-
Toluene	3.9x100	7.7x10-1	5.0x10-2	5.0x10-2	9.2x10-1	-
Trichloroethylene	2.5x101	9.8x100	-	-	5.5x10-4	-
Vinyl Acetate	4.4x10-2	5.9x10-3	-	-	5.0x10-5	-
Xylene	1.5x103	1.2x101	1.6x10-1	1.6x10-1	1.4x100	-

a. Source: WSRC (1994a).
b. Maximum operational air pollutant emissions projected for baseline year 1995. Concentration estimates based on actual emissions from all SRS sources for calendar year 1990 plus maximum potential emissions for sources permitted through December 1992.
c. NA= Emissions data currently unavailable.
- No proposed incremental emissions.

consist of about 2 y 10-7 curies per year of cesium-137. Releases from dry storage activities under these alternatives would be somewhat less. For Alternative 5 where SRS would manage about 2,740 MTHM (3,020 tons) of spent fuel (versus about 206 to 257 MTHM [227 to 283 tons] for the other alternatives), the atmospheric releases of cesium-137 would be proportionally higher.

DOE used actual emissions from F- and H-Areas during 1985 and 1986, a period when the SRS was processing material through the separations facilities at close to maximum capacity to evaluate potential releases from spent nuclear fuel management activities. DOE believes that the isotopes released during this period, and their emission rates, represent maximum emissions that could occur under any of the alternatives (Table 5-7). The results of the analyses are presented in this section and the human health consequences are discussed in Section 5.12. Section 5.15 presents the analysis of the consequences of accidents.

Construction Emissions. Potential impacts to air quality from construction activities would include fugitive dust from the clearing of land, as well as exhaust emissions from support equipment (e.g., earth-moving vehicles, diesel generators). The amount of dust produced would be proportional to the land area disturbed for the new facilities, all of which would be located near the center of the Site. The areas affected by each alternative would be as follows:

- No Action - 0 acres
- Decentralization, 1992/1993 Planning Basis and Regionalization A (by fuel type) - 6 to 9 acres

- Regionalization B (by location) - 7 to 11 acres
- Centralization - 70 to 100 acres
- Shipping fuel offsite - 1 acre

DOE anticipates that overall construction impacts to air quality would be minimal and of a short duration (6 months to 3 years). The SRS sitewide compliance with state and Federal ambient air quality standards would not be affected by any construction-related activities associated with spent fuel management.

Table 5-7. Estimated maximum annual emissions (in curies) of radionuclides to the atmosphere from spent nuclear fuel management activities.

Radionuclide	Annual Emissionsa,b
Tritium (elemental)	1.88x105,c
Cesium-134	3.60x10-4
Cesium-137	4.07x10-3
Curium-244	2.00x10-4
Cerium-141	1.83x10-3
Cerium-144	3.11x10-2
Americium-241	2.27x10-4
Cobalt-60	4.00x10-6
Plutonium-238	1.28x10-3
Plutonium-239	4.01x10-4
Strontium-90	1.39x10-2
Rubidium-103	7.25x10-3
Uranium-235	2.00x10-3
Osmium-185	3.60x10-4
Nibium-95	2.89x10-2
Selenium-75	1.52x10-5
Zirconium-95	1.68x10-2
Rubidium-106	5.12x10-3
Krypton-85	6.80x105
Carbon-14	2.80x101

a. Source: Hamby (1993).
b. Source terms are taken from 1985/86 F-/H-Area releases.
c. Historically, less than 10 percent of the atmospheric tritium releases have been from processing operations in the F-/H-Area Canyons.

5.7.1 Alternative 1 - No Action

The SRS would not process any spent nuclear fuel under the No Action alternative. Normal site baseline emissions would continue (Tables 5-3, 5-4, 5-5, 5-6 and 5-7). DOE would not construct any new facilities under this alternative.

5.7.2 Alternative 2 - Decentralization

Atmospheric emissions under two of the Decentralization options (dry storage and wet storage) would be similar to those for No Action. Those from the processing of the spent fuel (Option 2c) would be of somewhat higher concentrations (Tables 5-3, 5-4, 5-5, 5-6 and 5-7). The emissions would originate from existing facilities involved in the management of spent fuel under this alternative as well as new ones that DOE would construct (Figure 3-2).

5.7.3 Alternative 3 - 1992/1993 Planning Basis

Emissions to the atmosphere would be similar to those for Alternative 2 because the amount of fuel managed would be similar [223 and 220 MTHM (246 and 243 tons), Alternative 3 and Alternative 2 respectively] and the facilities required would be the same (Figure 3-2).

5.7.4 Alternative 4 - Regionalization

Regionalization A (by fuel type). Atmospheric emissions would be similar to the releases from Alternative 2 because of the similarity in volumes of fuel managed [213 and 220 MTHM (235 and 243 tons), respectively] and in the facilities involved (Figure 3-2).

Regionalization B (by location). Emissions would be somewhat higher than for Regionalization A for both dry and wet storage options if the SRS receives all the spent fuel in the eastern portion of the country, because the Site would manage about 20 percent more fuel. Atmospheric emissions from processing would not change from those under other alternatives because the amount of aluminum-clad fuel involved would be the same. Facility requirements would also be similar (Figure 3-2).

Shipping all of the current SRS inventory off the Site (Option 4g) would result in the lowest emissions to the atmosphere of any of the options under this alternative. These releases would result from the characterization and canning of the fuel prior to shipment.

5.7.5 Alternative 5 - Centralization

The atmospheric emissions resulting from centralizing all the spent nuclear fuel at the SRS would be the greatest of all the alternatives. The Site would manage about 2,740 MTHM (3,020 tons) of fuel. Releases from storage activities for centralization would be proportionally higher than for the other alternatives where the SRS would manage about 206 to 257 MTHM (227 to 283 tons) of spent fuel. However, emissions from processing under Alternative 5 would be similar to those under the other alternatives because the same amount of aluminum-clad fuel would be processed in each case. The facilities required under all three options would be similar in function (Figure 3-2) but of much larger capacity than for other alternatives.

Shipping all the SRS fuel to another site (Option 5d) would result in the lowest level of atmospheric releases of any alternative, similar to those under Regionalization B, Option 4g.

5.8 Water Quality and Related Consequences

SRS use of surface-water and groundwater resources under any of the alternatives would not substantially increase the volumes currently used for process, cooling, and domestic water on the Site. Table 5-8 summarizes the groundwater and surface water usage requirements for each alternative and option, and compares them to current SRS usages.

The Centralization Alternative (Option 5c), under which DOE would transfer all spent nuclear fuel to the SRS, would result in the largest amount of water use [approximately 378.5 million liters (100 million gallons) per year], which is a small amount compared to current SRS water requirements **of approximately 89.7 billion liters (23.7 billion gallons) per year.** This represents an increase of approximately 0.4 percent above current usage. Therefore, DOE anticipates that water use under any of the alternatives would have minimal impact on the water resources of the Site.

The impact on water quality of the operation of any of the alternatives would also be minimal. Existing SRS treatment facilities could accommodate all new spent fuel-related domestic and process wastewater streams. The expected total SRS flow volumes would still be well within the design capacities of the Site treatment systems. Because these plants would continue to meet National Pollutant Discharge Elimination System limits and reporting requirements, DOE expects no impact on the water quality of the receiving streams. The increased cooling water flows would also meet all discharge permit limits and would have minimal impacts on the receiving water.

Each of the alternatives would contribute to the very small releases of radionuclides that normal SRS operations discharge to the surface water through federally permitted wastewater outfalls.

Table 5-8. Annual groundwater and surface water usage requirements for each alternative. ,b

Alternative	Groundwater Usage per Year	Surface Water Usage per Year	Total Annual
Current SRS Usage	14.0 billion liters	75.7 billion liters	89.7 billion liters
No Action			
Option 1 - Wet Storage	35.1 million liters	None	35.1 million liters
Decentralization			
Option 2a - Dry Storage	48.7 million liters	6.1 million liters	54.8 million liters
Option 2b - Wet Storage	50.6 million liters	7.2 million liters	57.8 million liters
Option 2c - Processingc	48.7 million liters	310.8 million liters	359.5 million liters
Planning Basis			
Option 3a - Dry Storage	48.7 million liters	6.1 million liters	54.8 million liters
Option 3b - Wet Storage	50.6 million liters	7.2 million liters	57.8 million liters
Option 3c - Processingc	48.7 million liters	310.8 million liters	359.5 million liters
Regionalization - A			
Option 4a - Dry Storage	48.7 million liters	6.1 million liters	54.8 million liters
Option 4b - Wet Storage	50.6 million liters	7.2 million liters	57.8 million liters
Option 4c - Processingc	47.6 million liters	308.8 million liters	356.5 million liters
Regionalization - B			
Option 4d - Dry Storage	48.7 million liters	6.1 million liters	54.8 million liters
Option 4e - Wet Storage	50.6 million liters	7.2 million liters	57.8 million liters
Option 4f - Processingc	48.7 million liters	310.8 million liters	356.5 million liters
Option 4g - Ship Outc	38.1 million liters	3.0 million liters	41.1 million liters
Centralization			
Case 5a - Dry Storage	67.7 million liters	6.1 million liters	73.8 million liters
Case 5b - Wet Storage	69.6 million liters	7.2 million liters	76.8 million liters
Case 5c - Processingc	67.7 million liters	310.8 million liters	378.5 million liters
Case 5d - Ship Outc	38.1 million liters	3.0 million liters	41.1 million liters

a. Source: WSRC (1994b).
b. To convert liters to gallons, multiply by 0.26418.
c. First 10 years only.

Table 5-9 summarizes the estimated maximum amounts of radioactivity that could be released to the **Savannah River in liquid effluents from normal spent nuclear fuel management activities.** DOE used actual liquid releases from F- and H-Area during 1985 and 1986 to estimate potential releases that could occur during spent fuel management activities. DOE believes the isotopes and amounts released during this period are representative of releases that could occur during processing under any of the alternatives. This is because 1985 and 1986 represent periods when the F- and H-Area separations facilities operated at or near peak capacity to process spent nuclear fuel. Estimated releases from wet or dry storage would be less than these amounts. Consequently, the estimated releases given in Table 5-9 represent the upper limit of liquid radiological releases that DOE expects as a result of spent

Table 5-9. Estimated maximum liquid radiological releases (in curies) to the Savannah River from spent nuclear fuel management activities.

Radionuclide	Annual Releasea,b
Tritium	1.3x104,c
Strontium-90	2.4x10-1
Iodine-129	2.2x10-2
Cesium-137	1.1x10-1
Plutonium-239	7.0x10-3

a. Source: Hamby (1993).
b. Source terms are taken from 1985/86 F-/H-Area releases.

c. Less than 1 percent of this quantity was from processing operations in F-/H-Area.

nuclear fuel management activities. The consequences to human health due to these releases are discussed in Section 5.12, Occupational and Public Health and Safety.

Construction of new facilities under any alternative would require amounts of water that would be only a very small percentage of the current daily water use at the SRS. Good engineering practice measures would prevent sediment runoff or spills of fuel or chemicals. Therefore, construction activities should have no impact on surface or groundwater quality at the Site.

DOE also analyzed the potential impacts of accidents in F- and H-Areas on surface and groundwater quality. The analysis evaluated two types of accidental releases: one to the ground surface (e.g., overflow of a wet storage pool) and another directly to the subsurface (e.g., failure of a pool liner). Because pool water could contain some radionuclides, but would not contain any toxic or harmful chemicals, the following evaluation addresses only the consequences of radionuclide releases.

A release of pool water onto the ground from the Receiving Basin for Offsite Fuels, in H-Area, would not flow directly into any stream or other surface-water body. The building is in a graded, gravel-covered area among other buildings and alongside a railroad spur and access road. A tank farm surrounded by an earthen berm is immediately to the south. A channelized drainage ditch begins approximately 244 meters (800 feet) west of the basin building and passes through culverts under a railroad line and Road E before emptying into a tributary of Fourmile Branch about 500 meters (1,650 feet) from the Receiving Basin. The grading at the Site would contain a small volume of water overflowing the basin in the immediate area of the building. In the unlikely event that a larger spill reached the drainage ditch to the west, DOE could contain the water by blocking either of the two culverts through which the drainage ditch passes. After containing the spilled water, DOE could remove and properly dispose of it. DOE would design and construct new facilities containing storage pools in a manner that would confine any overflow or other surface release of pool water. Therefore, DOE believes that there will be no direct release to surface water from spills of pool water at an existing or potential facility.

An overflow from a pool could reach the groundwater by slowly flowing downward from the surface through the unsaturated zone until it reached the water table, which is 9 to 15 meters (30 to 50 feet) below the grade in the F- and H-Areas. Overflow water would take several years to reach the water table, based on a vertical velocity of between 0.9 and 2.1 meters (3 to 7 feet) per year (DOE 1987). As discussed in the following paragraphs, once in the groundwater, a plume would take many years to reach either of the closest surface-water bodies, Fourmile Branch to the south or Upper Three Runs Creek to the north.

DOE has calculated the travel times of groundwater in the F- and H-Areas based on specific information on the hydraulic conductivity, the hydraulic gradient, and the effective porosity of aquifers in this area (WSRC 1993a) and on the use of Darcy's Law. Water would take between 16 and 500 years to travel 1.6 kilometers (1 mile) toward Fourmile Branch or Upper Three Runs Creek. These estimates of travel time agree with values obtained from the results of DOE modeling studies performed on the F- and H-Areas (Geotrans 1993; appended to WSRC 1993a). The reason for this wide range of potential travel time is that the hydraulic conductivity of aquifer materials is highly variable and can vary in the same aquifer by several orders of magnitude. This slow movement through the subsurface, either vertically through the unsaturated zone or horizontally within the aquifer, would facilitate the removal of radionuclides from the spill plume through a number of processes. These include radioactive decay, trapping of particulates in the soil, and ion exchange and adsorption by the soil (Hem 1989). DOE believes that travel time of a contaminant plume through the subsurface in the F- or H-Area or in the adjacent representative host site would be such that no radionuclides would reach Fourmile Branch, Upper Three Runs Creek, or any other surface-water body by this route. For the same reasons, no radioactive contaminants introduced into the subsurface in these areas would move off the Site in groundwater.

DOE does not believe that releases of radionuclides such as those described above would reach SRS drinking-water sources that lie in deep aquifers under the Site. These aquifers are several hundred feet below the ground surface, and a number of thick aquifers and aquitards separate them from the water table aquifer (see Section 4.8). In addition to the distances and the presence of confining layers, vertical flow in the intervening stratified sedimentary aquifers is slow in comparison to horizontal flow. Radionuclide contamination of offsite drinking water sources is even more unlikely given the depth of their source aquifers, the distances involved, and the attenuation of contaminants in the soils, as described above.

DOE also evaluated a second kind of unintentional release in the F- or H-Area, a direct leak to the subsurface from a breach in a storage pool during routine operations. The analysis assumed a 19-liter (5-gallon)-per-day leak as a result of secondary containment or piping failure at a new state-of-the-art wet storage and fuel transfer facility (Creed 1994). The analysis assumed further that the leak would go undetected for 1 month, a conservative assumption given the sensitivity of the leak detection equipment that these new facilities would require. The reliability and sensitivity of the leak detection devices would be equal to or superior to those required by the U.S. Nuclear Regulatory Commission (NRC 1975) for spent nuclear fuel storage facilities in commercial nuclear power plants. DOE would require spent nuclear fuel storage pools (whether fuel unloading pools or storage basins) to have leak detection monitoring devices, pool water level monitors, and radiation monitors designed to alarm both locally and in a continuously staffed central location. Constant process monitoring, mass balance, and facility design (including double-walled containment of vessels and piping) would also be used by DOE to limit operational releases from new wet storage facilities, including fuel unloading pools and storage basins, to near zero.

To provide a common basis for analysis of spent nuclear fuel alternatives at its various sites, DOE developed a generic infrastructure design for a hypothetical spent nuclear fuel complex (Hale 1994). This design includes proposed criteria for temporary wet storage basins, fuel loading and unloading pools, and transfer canals.

Based on the design criteria in Hale (1994), a leak from one of these basins if constructed in F- or H-Area could result in the introduction of radionuclide-contaminated water into the ground at depths as much as 13.4 meters (44 feet) below grade. Such a release would go directly to the water table aquifer or to the unsaturated zone above it, depending on the depth of the water table. In either case, the processes governing the slow plume movement (i.e., the hydraulic conductivity, hydraulic gradient, and effective porosity of aquifers in the F- and H-Areas) and the processes resulting in the attenuation of contaminants and radionuclides (i.e., radioactive decay, trapping of particulates in the soil, ion exchange in the soil, and adsorption to soil particles) described in the previous paragraphs would also prevent or mitigate impacts to surface-or groundwater resources from releases of this type. There could be localized contamination of groundwater in the surface aquifer in the immediate vicinity of the storage facilities. This aquifer is not used as a source of drinking water. DOE believes that no radionuclide contamination of deeper confined aquifers that are sources of onsite or offsite drinking water could occur from a release of this type. And, as noted earlier, these wet storage facilities would be equipped with state-of-the-art leak detection devices, pool level monitors, and radiation monitors that would limit and mitigate any subsurface releases.

5.8.1 Alternative 1 - No Action

5.8.1.1 Option 1 - Wet Storage. During operations under this alternative, current levels of

water usage would not change. Nor would changes occur in thermal discharges from cooling water or the quantity or quality of radioactive and nonradioactive wastewater effluents.

The viable accidents under this alternative would be a release of pool water onto the ground surface or a breach of the liner of the wet storage basins in which the spent nuclear fuel would be stored. As discussed above, radionuclides in the released water would enter the water table aquifer but would not reach any surface-water or any drinking water aquifer on or off the SRS. Basin water contains no toxic or hazardous chemicals. Therefore, accidental releases from the basins would have minimal impacts on surface- and groundwater resources.

Spills of chemicals would not reach surface- or groundwater due to existing proper engineering design and environmental controls, and to rapid containment and cleanup.

5.8.2 Alternative 2 - Decentralization

Operations under either the dry or wet storage option for the Decentralization alternative would increase Site water usage by less than 0.1 percent above current levels. Processing would increase use by about 0.4 percent. Release of nonradioactive and radioactive materials to surface waters would increase only slightly and would be well within discharge permit limits and DOE dose limits. There would be no releases to groundwater during normal operations. Overall impacts to water quantity and water quality would be minimal.

Impacts to water resources due to accidental releases onto the ground or into the subsurface would also be minimal as explained above. Potential contamination would be limited to the surface aquifer.

5.8.3 Alternative 3 - 1992/1993 Planning Basis

DOE expects that the impacts to water resources under the dry storage, wet storage, and processing cases for this alternative would be similar to those described for the same options under Alternative 2, Decentralization. Overall impacts would be minimal.

5.8.4 Alternative 4 - Regionalization

DOE expects that the impacts to water resources under the three options for regionalization by fuel type (Regionalization A) would be similar to those described for the same options under Alternative 2, Decentralization. Regionalization B (by geographic location) would result in impacts somewhat greater than those for Alternative 2 because the SRS would have to manage an additional 37 MTHM (41 tons) of spent fuel. In either case, overall impacts would be minimal. For Option 4g, shipping all SRS fuel to Oak Ridge Reservation, impacts to water resources would be the smallest of any alternative, similar to those for Option 5d - Centralization.

5.8.5 Alternative 5 - Centralization

The first three options for this alternative - dry storage (Option 5a), wet storage (Option 5b), and processing (Option 5c) - assume that DOE would transfer all spent nuclear fuel to the SRS for management. The impacts of operations to water resources under these options would be similar in nature to the impacts for the same options under Alternative 2, Decentralization, as described in Section 5.8.2. However, the extent of the impacts would be greater because the number and size of facilities that DOE would construct and operate and the quantities of fuel it would manage would be larger than those for any other alternative. Even so, DOE expects the overall impacts of construction and operation to be minor. For example, the total volume of water that the SRS would withdraw for construction, cooling, processing, and domestic use under any of these three options would not exceed approximately 378.5 million liters (100 million gallons) per year. This requirement would be approximately 0.4 percent of the 89.7 billion liters (23.7 billion gallons) that the SRS currently uses annually.

Similarly, DOE believes that the overall impacts of accidents under any of these three options would be minor, even though the number and size of the facilities would be greater under this alternative than for any other. Radionuclides released during an accident would not affect any surface-water or any drinking water aquifer. However, surface aquifer resources would receive contamination in the area of any release.

For Option 5d (shipping the spent nuclear fuel off the Site), impacts to water resources would be smaller than those for any other alternative or option. DOE would have to build only one new facility (for fuel characterization) and the spent fuel would remain at SRS only for the first part of the 40-year management period. Overall impacts would be minimal.

5.9 Ecology

DOE expects that construction impacts, which would include loss of some wildlife habitat due to land clearing, would be greatest under the Centralization Alternative, Dry Storage option. Representative impacts from operations would include disturbance and displacement of animals caused by movement and noise of personnel, equipment, and vehicles; however, these impacts would be minor under all the proposed alternatives. Construction and operation would not disturb any critical or sensitive habitat, nor would they affect any wetland areas. Releases of radionuclides to the environment from any of the proposed alternatives would be small and would not be expected to accumulate in aquatic or terrestrial ecosystems or measurably affect the health or viability of plant and animal communities.

5.9.1 Alternative 1 - No Action

Under this alternative, DOE could refurbish or modify existing wet storage facilities and would confine any activity to these facilities. As a consequence, DOE expects no impacts to ecological resources. Impacts of operations under this alternative would be minimal, limited to some minor disturbance of animals by vehicular traffic.

5.9.2 Alternative 2 - Decentralization

5.9.2.1 Option 2a - Dry Storage. This option would require some new construction, but any

construction activity would occur either within the boundaries of F- and H-Areas, which are already heavily developed, or adjacent to them. As a result, this construction would have little or no impact on ecological resources. There would be no impacts to wetlands, threatened or endangered species, socially or commercially important species (such as the eastern wild turkey), or disturbance-sensitive species (such as wood warblers and vireos). Impacts of operations under this option would be limited to some minor disturbance of animals by slight increases in vehicular traffic. No threatened, endangered, or candidate species occur in the area of operations. Species likely to be disturbed or killed by vehicles (e.g., cotton rat, gray squirrel, opossum, and white-tailed deer) are common to ubiquitous in the area. Overall impact to ecological resources would be minimal.

5.9.2.2 Option 2b - Wet Storage. Construction impacts would be similar to those described

for dry storage (Option 2a). Impacts of operations under this option would also be similar to those described for dry storage (Option 2a). Overall impacts to ecological resources would be minimal.

5.9.2.3 Option 2c - Processing and Storage. Construction and operations impacts for this

option would also be similar to those for dry storage (Option 2a). Overall impacts would still be minimal.

5.9.3 Alternative 3 - 1992/1993 Planning Basis

Both construction and operational impacts for the three options under this alternative would be similar to those described for Alternative 2 - Decentralization. Overall impacts would be minimal.

5.9.4 Alternative 4 - Regionalization

Under the Regionalization A alternative, impacts to ecological resources would be minimal as described for Alternative 2. Impacts due to the Regionalization B options would be somewhat greater due to the larger volume of spent fuel that the SRS would manage. Overall impacts would still be minimal, however.

The smallest impacts would occur under Option 4g because DOE would ship all spent fuel off the Site.

5.9.5 Alternative 5 - Centralization

5.9.5.1 Option 5a - Dry Storage. The discussion that follows assumes that any facility

development would take place in an area that does not contain any pristine wetlands, old growth timber, threatened and endangered species, or designated critical habitat. More specifically, because the upland areas south and east of H-Area are dominated by planted pine (primarily loblolly and slash) stands, the discussion of impacts assumes that any facility development in support of spent nuclear fuel management would take place in an area of 5- to 40-year-old pines. Finally, the analysis assumes that any facility development would require a site-specific National Environmental Policy Act (NEPA) review as required under 10 CFR Part 1021 and in accordance with the Council on Environmental Quality's NEPA implementing regulations (CFR 1991b).

The proposed interim dry storage facility and support facilities, requiring approximately 0.28 square kilometers (70 acres) to 0.4 square kilometer (100 acres) of land, would be built somewhere within the largely wooded roughly 2.8 square kilometer (700-acre) area south and east of H-Area west of F-Road, and north of Fourmile Branch. This area has a number of advantages; among them: it would be relatively easy to connect with existing utilities (gas, water, sewer); it would minimize the amount of supporting infrastructure (e.g., railroad spurs, access roads, and transmission lines) that would have to be built; and it would enable DOE to consolidate spent nuclear fuel management activities in an area that has been altered many times over the years by farming (before 1951) and timber management activities (after 1951).

Construction activities would result in the clearing of as much as approximately 0.4 square kilometer (100 acres) of planted 5- to 40-year-old loblolly or slash pine for new facilities on the undeveloped representative host site south and east of H-Area. This land clearing would involve a relatively small number of loggers and heavy equipment operators, but probably would drive most birds and larger, more mobile animals from the area. Some smaller, less mobile animals, such as turtles, toads, lizards, mice, and voles, probably would be killed. Aside from the loss of 0.28 to 0.4 square kilometer (70-100 acres) of planted pines that provide habitat for a limited number of reptiles, birds, and mammals, construction impacts would be minor.

Any land clearing and timber harvesting conducted on the undeveloped host site would be carefully planned and conducted according to widely accepted Best Management Practices to minimize erosion and soil loss and to prevent impacts to downgradient wetlands and streams. DOE and SRS policy is to achieve "no net loss" of wetlands. DOE has issued a guidance document, Information for Mitigation of Wetlands Impacts at the Savannah River Site (DOE 1992), for project planners that puts forth a practical approach to wetlands protection that begins with avoidance of impacts (if possible), moves to minimization of impacts (if avoidance is impossible), and requires compensatory measures (wetlands restoration, creation, enhancement, or acquisition) in the event that impacts cannot be avoided.

In the event that new facility development was required, DOE would perform predevelopment surveys to ensure that its activities would not affect threatened and endangered species or sensitive habitats. To the extent practicable, land clearing and timber harvesting would be restricted to times of the year when songbirds and game birds were not nesting or rearing young. In South Carolina, most songbirds nest, rear, and fledge young from March to September (Sprunt and Chamberlain 1970). Quail, dove, and wild turkey in the region normally nest and fledge young during the spring and summer (Sprunt and Chamberlain 1970).

No threatened or endangered plants or animals are known to be present in the area under consideration for development. Construction activities probably would not affect two small wetlands (Carolina bays) lying in the east-central portion of the undeveloped host site. Construction activities would not affect plant and animal diversity locally or regionally, because the managed loblolly and slash pine stands that would be removed are not unique, nor do they provide habitat for any protected, sensitive, unusual, or Federally listed plant or animal species.

Impacts of operations under this option would be similar to, but slightly greater than, those described for Option 2a. Overall impacts to ecological resources would be minor.

5.9.5.2 Option 5b - Wet Storage. Construction impacts under this option would be less than

those described for Option 5a because less land area would be required for new facilities. Impacts of operations under this case would be similar to those described for Option 5a. Overall impacts to ecological resources would be minor.

5.9.5.3 Option 5c - Processing and Storage. Construction impacts under this case would

be similar to those described for Option 5a. This case would require the largest number of workers of all the cases under consideration. It would result in more noise, more traffic, and a generally higher level of disturbance to terrestrial wildlife (specifically reptiles, songbirds, and small and large mammals) accustomed to feeding, foraging, perching, hunting, nesting, or denning in the area. Some animals would be driven from the area permanently, while others probably would become accustomed to the increased noise and activity levels, and would return to the area. Overall impacts to ecological resources would be minor.

5.9.5.4 Option 5d - Shipment off the Site. Construction impacts under this case would be

smaller than those for any other alternative, excluding Alternative 1 - No Action. Impacts of operation under this case would also be minimal, limited to some minor disturbances of animals by vehicular traffic. Overall impacts to ecological resources would be minimal.

5.10 Noise

As described in Section 4.10, noises generated on the SRS do not travel off the Site at levels that affect the general population. Therefore, SRS noise impacts for each alternative would be limited to noise resulting from the transportation of personnel and materials to and from the Site that could affect nearby communities and from onsite sources that could affect some wildlife near these sources. DOE would address the effects of noise on wildlife near spent nuclear fuel management facilities under any alternative in a project-specific NEPA evaluation.

Transportation noises would be a function of the size of the workforce (i.e., an increased workforce would produce increased employee traffic and corresponding increases in deliveries by truck and rail and a decreased workforce would produce decreased employee traffic and corresponding decreases in deliveries). The analysis of traffic noise took into account railroad noise and noise from the major roadways that provide access to the SRS. DOE does not expect the number of freight trains per day in the region and through the Site to change as a result of any of the alternatives, although some trains could be dedicated to the transport of spent nuclear fuel. Rail shipments of spent nuclear fuel, regardless of the alternative, would not substantially increase the rail traffic on the CSX line through the SRS. Therefore, vehicles used to transport employees and personnel on roadways would be the principal sources of community noise impacts. This analysis used the day-night average sound level (DNL) to assess community noise, as suggested by the Environmental Protection Agency (EPA 1974; 1982) and the Federal Interagency Committee on Noise (FICON 1992). The analysis based its estimate of the change in day-night average sound level from the baseline noise level for each alternative on the projected changes in employment and traffic levels. The baseline levels are those for 1995. The analysis also considered the combination of construction and operation employment. The traffic noise analysis considered SC 125 and SC 19, both of which are used to access the SRS. Changes in noise level below 3 decibels would not be likely to result in a change in community reaction (FICON 1992).

DOE projects no new employment due to operations for any of the alternatives. Some additional construction jobs may be required but overall SRS employment would not exceed the 1995 baseline levels, except for Alternatives 5a, 5b, and 5c. The maximum Site employment of about 20,000 jobs would occur in 1995 for all alternatives except 5a, 5b, and 5c for which the peak would occur in about 2002 due to a peak in construction employment. The general decrease in employment after 1995 could result in some decrease in vehicle trips to and from the Site. There would be at most a few truck trips per day to and from the Site carrying spent nuclear fuel under any of the alternatives. This increase in truck trips would not result in a perceptible increase in traffic noise levels along the routes to the SRS. The day-night average sound level along SC 125 and SC 19 and other access routes would probably decrease slightly except in the peak construction years under Alternatives 5a, 5b, and 5c, as a result of the overall decrease in employment levels at the SRS after 1995. DOE expects no change in the community reaction to noise along these routes. Consequently, no mitigation efforts are necessary.

5.11 Traffic and Transportation

This section discusses the consequences of both the onsite transportation of spent nuclear fuel and the increased traffic patterns due to construction activities at the SRS. Traffic due to operations of spent nuclear fuel facilities will remain at or below current Site levels because workers for the new activities will be drawn from the existing SRS workforce. The consequences of the transportation of spent fuel between the SRS and other DOE sites are described in Appendix I of Volume 1 of this Environmental Impact Statement (EIS).

5.11.1 Traffic

Traffic impacts would be bound by Alternative 5b (Centralization - Wet Storage) which would result in the greatest number of additional construction workers (and vehicles) onsite. Level of service, a measure of traffic flow, was estimated for each road to and from the SRS. Traffic delays could be experienced at SC 19 and SC 230 intersections during peak hours. However, the number of construction vehicles in support of spent nuclear fuel construction activities would contribute less than 17 percent (HNUS 1994) to the total traffic flow. Therefore, the change in level of service due to Alternative 5b would be minimal.

5.11.2 Transportation

This section discusses the potential radiological consequences due to incident free transportation and accidents during transport. All SRS onsite shipments are carried out by rail.

5.11.2.1 Onsite Spent Nuclear Fuel Shipments. DOE based the number of fuel

shipments on the amount and type of spent nuclear fuel stored at various SRS locations and the final storage location or disposition specified in the spent nuclear fuel alternatives. The number of shipments from each location was determined by dividing the amount of spent nuclear fuel at each location by the capacity of the shipping cask. Individual shipments from the various facilities were summed to obtain the total number of shipments for each alternative (HNUS 1994).

Onsite shipments are those that originate and terminate at the SRS. Movements of spent nuclear fuel within functional areas (e.g., H-Area or F-Area) are operational transfers, not onsite shipments; therefore, this analysis does not consider them.

5.11.2.2 Incident-Free Transportation Analysis. Under each alternative, DOE analyzed

incident-free (normal transport) radiological impacts to transport vehicle crews and members of the general public from onsite rail shipments. The analysis calculated occupational radiation doses to the transport vehicle crew members (four locomotive operators). Because the general public does not have immediate access to areas where the SRS would transport spent nuclear fuel, the analysis assumed that any general public dose is to escorted individuals on the Site waiting at any of several train crossings at the time a fuel shipment passed. The analysis calculated radiological doses to the general public using the Riskind (Yuan et al. 1993) computer code. The results are presented in Table 5-10.

The magnitude of incident-free consequence depends on the dose rate on the external surface of the transport vehicle, the exposure time, and the number of people exposed. For each receptor, the analysis assumed the external dose rate 2 meters (6.6 feet) from the shipping cask was 100 millirem per hour (HNUS 1994), which is the SRS procedurally-allowed maximum dose rate during onsite fuel shipments. Actual receptor dose rates would depend on receptor distance from the shipping cask [5 meters (16.4 feet) for the general public]. The duration of exposure would depend on the transport vehicle speed and the number of shipments. In addition, occupational exposure time would depend on the distance of each shipment.

The analysis calculated health effects measured as the number of latent cancer fatalities (LCFs) by multiplying the resultant occupational and general public doses by risk factors of 4 x 10-4 and 5 x 10-4 latent cancer fatalities per person-rem (DOE 1993a), respectively.

Table 5-10 summarizes the collective doses (person-rem) and health effects (latent cancer fatalities) associated with the incident-free onsite shipment of spent nuclear fuel at the SRS. Collective

Table 5-10. Collective doses and health effects for onsite, incident-free spent nuclear fuel shipments by alternative.

Option	Occupational (person-rem)	General Public (person-rem)	Number of LCFsa

			Occupational	General Public
No Action				
Option 1b -Wet Storage	1.5x100	1.4x10-1	6.0x10-4	7.0x10-5
Decentralization				
Option 2a - Dry Storage	2.5x100	2.3x10-1	1.0x10-3	1.2x10-4
Option 2b - Wet Storage	2.5x100	2.3x10-1	1.0x10-3	1.2x10-4
Option 2c - Processing	5.3x10-1	3.7x10-2	2.1x10-4	1.9x10-5
Planning Basis				
Option 3a - Dry Storage	2.5x100	2.3x10-1	1.0x10-3	1.2x10-4
Option 3b - Wet Storage	2.5x100	2.3x10-1	1.0x10-3	1.2x10-4
Option 3c - Processing	5.3x10-1	3.7x10-2	2.1x10-4	1.9x10-5
Regionalization				
Option 4a - Dry Storage	2.5x100	2.3x10-1	1.0x10-3	1.2x10-4
Option 4b - Wet Storage	2.5x100	2.3x10-1	1.0x10-3	1.2x10-4
Option 4c - Processing	5.3x10-1	3.7x10-2	2.1x10-4	1.9x10-5
Option 4d - Dry Storage	2.5x100	2.3x10-1	1.0x10-3	1.2x10-4
Option 4e - Wet Storage	2.5x100	2.3x10-1	1.0x10-3	1.2x10-4
Option 4f - Processing	5.3x10-1	3.7x10-2	2.1x10-4	1.9x10-5
Option 4g - Ship Out	NAb	NAb	NAb	NAb
Centralization				
Option 5a - Dry Storage	2.5x100	2.3x10-1	1.0x10-3	1.2x10-4
Option 5b - Wet Storage	2.5x100	2.3x10-1	1.0x10-3	1.2x10-4
Option 5c - Processing	5.3x10-1	3.7x10-2	2.1x10-4	1.9x10-5
Option 5d - Ship Out	NAb	NAb	NAb	NAb

a. LCF = latent cancer fatality.
b. NA = not applicable.

doses and latent cancer fatalities for members of the public would be approximately a factor of 10 less than those for the occupational worker. The data indicate that the lowest collective doses and lowest latent cancer fatality would be associated with the Processing option under the Decentralization, Planning Basis, Regionalization, and Centralization alternatives.

5.11.2.3 Transportation Accident Analysis. DOE analyzed radiological impacts from

potential accidents to both the onsite maximally exposed individual (MEI), and offsite members of the general public from onsite rail shipments. The analysis calculated doses using the Riskind (Yuan et al. 1993) computer code with site-specific meteorology, demographics, and spent fuel activity. Risk was calculated using site-specific rail accident rates and accident probabilities (HNUS 1994).

The magnitude of accident consequence would depend on the amount of radioactive material to which the individual(s) was exposed, the exposure time, and the number of people exposed. The analysis assumed that the maximum reasonably foreseeable amount of radioactive material for the type of spent fuel shipped on the SRS was released (HNUS 1994). The assumed duration of exposure for each receptor was 2 hours. The assumed maximally exposed individual was an SRS worker downwind of the accident at distances of 50 and 100 meters (164 and 330 feet).

The analysis calculated offsite exposure using both rural and suburban population density-specific census data. The rural and suburban population densities have an average of 6 persons per square kilometer and 244 persons per square kilometer, respectively. The west-northwest sector has the highest population density within 80 kilometers (50 miles) of the SRS.

The analysis used site-specific meteorology at the 50th and 95th percentile to determine dose consequences. Joint probability includes both the event frequency and the probability of the maximum reasonably foreseeable type of accident occurring.

The analysis calculated health effects measured as the number of latent cancer fatalities by multiplying the resultant occupational and general public doses by the risk factors of 4 x 10-4 and 5 x 10-4 latent cancer fatalities per person-rem (DOE 1993a), respectively. Risk was calculated by multiplying the resultant doses by the joint probability of 1 x 10-4 (HNUS 1994).

Tables 5-11 and 5-12 summarize the collective doses and associated latent cancer fatalities for postulated onsite rail accidents with subsequent releases of radioactive material to the environment. The dose consequences of an accidental release of radioactive material was assessed for the 95th and typical 50th percentile meteorological conditions (i.e., those that would result in lower doses 95 and 50 percent of the time, respectively). In all cases the estimated number of latent cancer fatalities would be low.

5.11.3 Onsite Mitigation and Preventative Measures

All onsite shipments must be in compliance with DOE Savannah River Directive Implementation Instruction 5480.3, "Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes." DOE, DOE-SR, or the Nuclear Regulatory Commission (NRC) must approve packages used for onsite shipments with a certificate of compliance. If DOE or NRC has not certified an onsite package as Type B, the shipper must establish administrative controls and site-mitigating circumstances that will ensure package integrity. The administrative and emergency response considerations must provide sufficient control so that accidents would not result in loss of containment, shielding, or criticality; or the uncontrolled release of radioactive material would not create a hazard to the health and safety of the public or workers.

Table 5-11. Impacts on maximally exposed individual from spent nuclear fuel transportation accident on the Savannah River Site.

Dose Percentile	Distance (meters)	Dose to MEIa (rem)	Number of LCFsb per year	Risk
50 percent	100	0.16	6.4x10-5	1.6x10-5
95 percent	50	0.37	1.5x10-4	3.7x10-5

a. MEI = maximally exposed individual.
b. LCF = latent cancer fatality.

Table 5-12. Impacts on offsite population from spent nuclear fuel transportation accident on the Savannah River Site.

Population Density Category	Dose Percentile	Offsite Population Dose (person-rem)	Number of LCFsa per year	Risk
Rural	50th	1.7	8.7x10-4	1.7x10-4
Rural	95th	7.1	3.6x10-3	3.6x10-3
Suburban	50th	5.2	2.6x10-3	2.6x10-3
Suburban	95th	21.3	1.1x10-2	1.1x10-2

a. LCF = latent cancer fatality.

In the event of an accident, SRS has established an emergency management program. This program incorporates activities associated with emergency planning, preparedness, and response.

5.12 Occupational and Public Health and Safety

5.12.1 Radiological Health

This human health effects analysis relied principally on data on F- and H-Area emissions documented for the 1985, 1986, and 1993 operating years (Marter 1986; 1987; WSRC 1994d). During the 1985-1986 period, F- and H-Areas processing facilities operated at high capacity; DOE believes, therefore, that these emissions represent conservative estimates as to the emissions that could result from spent nuclear fuel management activities at the SRS. This air and surface-water emissions information defined the source terms for the baseline evaluation (No Action alternative) of health effects discussed in this section. To estimate health effects, this analysis defined six human receptor groups:

- The F- and H-Area workers assigned to F- and H-Area operations involving nuclear materials
- The F- and H-Area workers assigned to the Receiving Basin for Offsite Fuels for storage operations
- The maximally exposed individual residing at the SRS boundary
- The projected 1994 offsite population of 628,200 persons residing within an 80-kilometer (50-mile) radius of F- and H-Areas
- The maximally exposed individual potentially affected by SRS surface-water emissions
- The approximate offsite population of 65,000 persons whom SRS surface-water emissions could affect.

With the exception of the worker group, this analysis calculated exposures for the remaining four receptor groups using the baseline source terms as input data to automated atmospheric and surface-water transport, human intake, and human dosimetry models configured for routine use at SRS

(Hamby 1994). The analysis estimated worker exposures using averaged dosimetry data recorded for F- and H-Area workers from 1983 through 1987 and Receiving Basin for Offsite Fuels workers for 1993 (Matheny 1994), corrected for an assumed occupancy factor of 0.25 (i.e., a worker could be potentially exposed during one-quarter of his/her shift). This correction was applied to the 1983-1987 data only. At the SRS, the waterborne exposure pathway does not exist for the worker receptor group because Site drinking water is drawn from deep aquifers unaffected by any radiological releases.

The analysis developed incremental receptor group exposure estimates (millirem per year, person-rem per year; effective dose equivalent) based on spent fuel quantities for each of the nonbaseline alternatives (i.e., Alternatives 2 through 5) and their options by applying calculated ratios of metric tons of heavy metal (MTHM) for each alternative and option compared to the No Action alternative. DOE used these ratios as incremental scaling factors to estimate exposures under each option. The calculation of the MTHM ratios used the data presented in Table 3-1. Table 5-13 lists the results of the exposure estimate calculations. Since these incremental exposures include contributions to the effective dose equivalent from existing (No Action) spent fuel management at the SRS, the change in health effects for each alternative can be estimated as the difference between the alternatives presented.

The analysis calculated the potential health effects expressed in the exposed receptor groups consistent with risk determination guidance issued by the DOE Office of NEPA Oversight (DOE 1993a) and International Commission on Radiological Protection Publication 60 (ICRP 1991). For exposed individuals and populations, the potential health effect (detriment) of interest is latent fatal cancer. For exposed individuals, this analysis presents the health effect as the maximum incremental probability for detriment expression; for exposed populations, it presents the annual incremental detriment incidence. For completeness, it also provides the "project life" (i.e., 40 years) detriment incidence as the annual incidence multiplied by 40. Table 5-14 (worker) and Table 5-15 (maximally exposed individual and offsite population) summarize the health effects calculations.

The Centers for Disease Control and Prevention is conducting a comprehensive reconstruction of historic offsite doses associated with SRS operations. The results of this investigation are not yet available.

5.12.2 Nonradiological Health

DOE used the operations air quality data listed in Tables 5-3, 5-4, 5-5 and 5-6 (and Table 8 of WSRC 1994a) to evaluate health impacts associated with potential exposure to the following two compound classes: criteria pollutants and toxic pollutants. The analysis evaluated two hypothetical receptor locations: (1) a worker in S-Area and (2) a maximally exposed individual at the SRS boundary. However, it was unnecessary to postulate an intake of criteria pollutant or toxic compounds by these receptors because airborne concentration standards are available for these compounds.

Tables 5-3 and 5-4 list 8 criteria pollutants and 23 toxic compounds. The toxic compounds were classified as carcinogens and noncarcinogens consistent with Environmental Protection Agency carcinogenicity group (weight of evidence) designations published in the Integrated Risk Information

Table 5-13. Incremental radioactive contaminant annual exposure summary.

Alternative	Onsite Workers[a] (mrem/year)[c]	(person-rem/year)	MEI Offsite[a,b,d] (mrem/year) Air	Water	Offsite Population[a,d] (person-rem/year) Air	Water
No Action - Wet Storage (Option 1)	100	0.2	9x10-8	3x10-8	4x10-6	6x10-7
Decentralization - Dry Storage	83	0.2	8x10-8			

(Option 2a)				2x10-8	3x10-6	5x10-7
Decentralization - Wet Storage (Option 2b)	104	0.2	9x10-8	3x10-8	4x10-6	6x10-7
Decentralization - Processing (Option 2c)	145	70	0.4	0.1	14	2.2
Planning Basis - Dry Storage (Option 3a)	84	0.2	8x10-8	2x10-8	3x10-6	5x10-7
Planning Basis - Wet Storage (Option 3b)	105	0.2	1x10-7	3x10-8	4x10-6	6x10-7
Planning Basis - Processing (Option 3c)	147	71	0.4	0.1	15	2.2
Regionalization A - Dry Storage (Option 4a)	83	0.2	8x10-8	2x10-8	3x10-6	5x10-7
Regionalization A - Wet Storage (Option 4b)	103	0.2	9x10-8	3x10-8	4x10-6	6x10-7
Regionalization A - Processing (Option 4c)	148	76	0.4	0.1	16	2.4
Regionalization B - Dry Storage (Option 4d)	105	0.2	1x10-7	3x10-8	4x10-6	6x10-7
Regionalization B - Wet Storage (Option 4e)	131	0.3	1x10-7	4x10-8	5x10-6	7x10-7
Regionalization B - Processing (Option 4f)	175	74	0.4	0.1	15	2.3
Regionalization B - Ship Out (Option 4g)	<100	<0.2	<9x10-8	<3x10-8	<4x10-6	<6x10-7
Centralization - Dry Storage (Option 5a)	1,102	2.2	1x10-6	3x10-7	4x10-5	6x10-6
Centralization - Wet Storage (Option 5b)	1,377	2.8	1x10-6	4x10-7	5x10-5	8x10-6
Centralization - Processing (Option 5c)	1,422	79	0.4	0.1	16	2.4
Centralization - Ship Out (Option 5d)	<100	<0.2	<9x10-8	<3x10-8	<4x10-6	<6x10-7

a. Insignificant digits are displayed for comparison purposes only.
b. MEI = maximally exposed individual.
c. The DOE administrative dose limit is 2,000 mrem (DOE 1994a).
d. Data is provided separately for the air and water exposure pathways because the receptors are not co-located.

Table 5-14. Incremental fatal cancer incidence and maximum probability for workers.

Alternative	Annual Incidence[a]	40-Year Incidence	Maximum Probability
No Action - Wet Storage (Option 1)	8x10-5	3x10-3	4x10-5
Decentralization - Dry Storage (Option 2a)	7x10-5	3x10-3	3x10-5
Decentralization - Wet Storage (Option 2b)	8x10-5	3x10-3	4x10-5
Decentralization - Processing (Option 2c)	3x10-2	1	6x10-5
Planning Basis - Dry Storage (Option 3a)	7x10-5	3x10-3	3x10-5
Planning Basis - Wet Storage (Option 3b)	8x10-5	3x10-3	4x10-5
Planning Basis - Processing (Option 3c)	3x10-2	1	6x10-5
Regionalization A - Dry Storage (Option 4a)	7x10-5	3x10-3	3x10-5
Regionalization A - Wet Storage (Option 4b)	8x10-5	3x10-3	4x10-5

Regionalization A - Processing (Option 4c)	3x10-2	1	6x10-5
Regionalization B - Dry Storage (Option 4d)	8x10-5	3x10-3	4x10-5
Regionalization B - Wet Storage (Option 4e)	1x10-4	4x10- -3	5x10-5
Regionalization B - Processing (Option 4f)	3x10-2	1	7x10-5
Regionalization B - Ship Out (Option 4g)	<8x10-5	<3x10-3	<4x10-5
Centralization - Dry Storage (Option 5a)	9x10-4	4x10-2	4x10-4
Centralization - Wet Storage (Option 5b)	1x10-3	4x10- -2	5x10-4
Centralization - Processing (Option 5c)	3x10-2	1	6x10-4
Centralization - Ship Out (Option 5d)	<8x10-5	<3x10-3	<4x10-5

a. Number of latent fatal cancers over a lifetime which could be attributed to one year of spent nuclear fuel management activities.

System (IRIS) data base (DOE 1994b). For purposes of health effects analysis, carcinogens are those compounds designated Group A (human carcinogens), Group B1 (probable human carcinogen, limited evidence in human studies), Group B2 (probable human carcinogen, inadequate evidence or no data from human studies), and Group C (possible human carcinogen). Using this designation, three of the 23 toxic compounds are carcinogens: benzene (Group A), formaldehyde (Group B1), and methylene chloride (Group B2).

Carcinogen health effects are expressed as the incremental probability of an individual developing cancer, assuming a lifetime (70 years) of exposure to the carcinogen. DOE used cancer risk (slope) factors published in IRIS (Integrated Risk Information System) to obtain unit risk factors (risk per concentration) needed to calculate incremental probability. Carcinogens with insufficient (i.e., incomplete or unavailable carcinogen assessment data) information listed in the Integrated Risk Information System data base precluded a quantitative risk assessment; this analysis evaluated them as noncarcinogens.

Table 5-15. Incremental fatal cancer incidence and maximum probability for the maximally exposed individual and offsite population (air and water pathways).

Alternative	Population Annual Incidence[a]	Population 40-Year Incidence	MEI Maximum Probability
No Action - Wet Storage (Option 1)			
Air	2x10-9	7x10-8	4x10-14
Water	3x10-10	1x10-8	1x10-14
Decentralization - Dry Storage (Option 2a)			
Air	2x10-9	6x10-8	4x10-14
Water	2x10-10	9x10-9	1x10-14
Decentralization - Wet Storage (Option 2b)			
Air	2x10-9	8x10-8	5x10-14
Water	3x10-10	1x10-8	2x10-14
Decentralization - Processing (Option 2c)			
Air	7x10-3	0.3	2x10-7
Water	1x10-3	4x10-2	6x10-8
Planning Basis - Dry Storage (Option 3a)			
Air	2x10-9	6x10-8	4x10-14
Water	2x10-10	9x10-9	1x10-14
Planning Basis - Wet Storage (Option 3b)			
Air	2x10-9	8x10-8	5x10-14
Water	3x10-10	1x10-8	2x10-14
Planning Basis - Processing (Option 3c)			
Air	7x10-3	0.3	2x10-7

Water	1x10-3	4x10-2	6x10-8
Regionalization A - Dry Storage (Option 4a)			
Air	2x10-9	6x10-8	4x10-14
Water	2x10-10	9x10-9	1x10-14
Regionalization A - Wet Storage (Option 4b)			
Air	2x10-9	8x10-8	5x10-14
Water	3x10-10	1x10-8	2x10-14
Regionalization A - Processing (Option 4c)			
Air	8x10-3	0.3	2x10-7
Water	1x10-3	5x10-2	6x10-8
Regionalization B - Dry Storage (Option 4d)			
Air	2x10-9	8x10-8	5x10-14
Water	3x10-10	1x10-8	2x10-14
Regionalization B - Wet Storage (Option 4e)			
Air	2x10-9	1x10-7	6x10-14
Water	4x10-10	1x10-8	2x10-14
Regionalization B - Processing (Option 4f)			
Air	8x10-3	0.3	2x10-7
Water	1x10-3	5x10-2	6x10-8
Regionalization B - Ship Out (Option 4g)			
Air	<2x10-9	<7x10-8	<4x10-14
Water	<3x10-10	<1x10-8	<1x10-14

Table 5-15. (continued).

Alternative	Population Annual Incidence[a]	Population 40-Year Incidence	MEI Maximum Probability
Centralization - Dry Storage (Option 5a)			
Air	2x10-8	8x10-7	5x10-13
Water	3x10-9	1x10-7	2x10-13
Centralization - Wet Storage (Option 5b)			
Air	3x10-8	1x10-6	6x10-13
Water	4x10-9	2x10-7	2x10-13
Centralization - Processing (Option 5c)			
Air	8x10-3	0.3	2x10-7
Water	1x10-3	5x10-2	6x10-8
Centralization - Ship Out (Option 5d)			
Air	<2x10-9	<7x10-8	<4x10-14
Water	<3x10-10	<1x10-8	<1x10-14

a. Number of latent fatal cancers over a lifetime that could be attributed to one year of spent nuclear fuel management activities.

This analysis evaluated noncarcinogenic and priority pollutant compound health effects by adding hazard quotients to obtain a hazard index. The hazard quotient is the ratio of compound concentration or dose to a Reference Concentration (RfC) or Dose (RfD) (EPA 1989). The regulatory standard used in this analysis was the more stringent of the following: (1) Occupational Safety and Health Administration (OSHA) 8-hour permissible exposure limit (PEL), (2) American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV), or (3) State of South Carolina air quality standards. The use of the noncancer hazard index assumed a level of exposure (i.e., RfC) below which adverse health effects are unlikely. The hazard index is not a statistical probability; therefore it cannot be interpreted as such.

Table 5-16 summarizes nonradiological health effects attributable to atmospheric emissions of toxic and criteria pollutant compounds. Because no hazard index value would exceed unity (1.0), adverse health effects are unlikely under any alternative.

5.12.3 Industrial Safety

This section describes the following measures of impact for workplace hazards: (1) total reportable injuries and illnesses and (2) fatalities in the work force. This analysis considers injury/illness and fatality incidence rates for construction workers separately because of the relatively more hazardous nature of construction work. Table 5-17 lists the incidence of injuries/illnesses and fatalities for construction and non-construction workers. These data are for the highest employment

Table 5-16. Nonradiological annual incremental health effects summary.

Alternative	Worker Cancer Probability[a]	Worker Hazard Index	MEI Cancer Probability[a,b]	MEI Hazard Index
No Action - Wet Storage (Option 1)	Insufficient data	2×10^{-6}	Insufficient data	2×10^{-7}
Decentralization - Dry Storage (Option 2a)	Insufficient data	2×10^{-6}	Insufficient data	2×10^{-7}
Decentralization - Wet Storage (Option 2b)	Insufficient data	2×10^{-6}	Insufficient data	2×10^{-7}
Decentralization - Processing (Option 2c)	Insufficient data	6×10^{-3}	Insufficient data	5×10^{-4}
Planning Basis - Dry Storage (Option 3a)	Insufficient data	2×10^{-6}	Insufficient data	2×10^{-7}
Planning Basis - Wet Storage (Option 3b)	Insufficient data	2×10^{-6}	Insufficient data	2×10^{-7}
Planning Basis - Processing (Option 3c)	Insufficient data	6×10^{-3}	Insufficient data	5×10^{-4}
Regionalization A - Dry Storage (Option 4a)	Insufficient data	2×10^{-6}	Insufficient data	2×10^{-7}
Regionalization A - Wet Storage (Option 4b)	Insufficient data	2×10^{-6}	Insufficient data	2×10^{-7}
Regionalization A - Processing (Option 4c)	Insufficient data	6×10^{-3}	Insufficient data	5×10^{-4}
Regionalization B - Dry Storage (Option 4d)	Insufficient data	2×10^{-6}	Insufficient data	3×10^{-7}
Regionalization B - Wet Storage (Option 4e)	Insufficient data	2×10^{-6}	Insufficient data	3×10^{-7}
Regionalization B - Processing (Option 4f)	Insufficient data	8×10^{-3}	Insufficient data	6×10^{-4}
Regionalization B - Ship Out (Option 4g)	Insufficient data	2×10^{-6}	Insufficient data	2×10^{-7}
Centralization - Dry Storage (Option 5a)	Insufficient data	2×10^{-6}	Insufficient data	2×10^{-7}
Centralization - Wet Storage (Option 5b)	Insufficient data	2×10^{-6}	Insufficient data	2×10^{-7}
Centralization - Processing (Option 5c)	Insufficient data	6×10^{-3}	Insufficient data	5×10^{-4}
Centralization - Ship Out (Option 5d)	Insufficient data	2×10^{-6}	Insufficient data	2×10^{-7}

a. Insufficient data exists in the IRIS data base to perform a quantitative inhalation cancer risk assessment.

b. MEI = maximally exposed individual.

year (i.e., maximum hours worked in any year from 1994 through 2035, assuming 2,000 hours per worker) (WSRC 1994b). This analysis used the average occupational injury/illness and fatality incidence rates experienced by DOE and its contractors from 1988 through 1992 to calculate the incidence of industrial hazards listed in Table 5-17 (DOE 1993b).

Table 5-17. Incremental industrial hazard maximum annual incidence summary.

Alternative	Construction Injuries and Illnesses	Construction Fatalities	Nonconstruction Injuries and Illnesses	Nonconstruction Fatalities
No Action - Wet Storage (Option 1)	92	<1	159	<1
Decentralization - Dry Storage (Option 2a)	71	<1	159	<1
Decentralization - Wet Storage (Option 2b)	71	<1	159	<1
Decentralization - Processing (Option 2c)	66	<1	159	<1
Planning Basis - Dry Storage (Option 3a)	71	<1	159	<1
Planning Basis - Wet Storage (Option 3b)	82	<1	159	<1
Planning Basis - Processing (Option 3c)	66	<1	159	<1
Regionalization A - Dry Storage (Option 4a)	82	<1	159	<1
Regionalization A - Wet Storage (Option 4b)	82	<1	159	<1
Regionalization A - Processing (Option 4c)	66	<1	159	<1
Regionalization B - Dry Storage (Option 4d)	89	<1	199	<1
Regionalization B - Wet Storage (Option 4e)	102	<1	199	<1
Regionalization B - Processing (Option 4f)	82	<1	199	<1
Regionalization B - Ship Out (Option 4g)	22	<1	159	<1
Centralization - Dry Storage (Option 5a)	316	1	159	<1
Centralization - Wet Storage (Option 5b)	337	1	159	<1
Centralization - Processing (Option 5c)	316	1	159	<1
Centralization - Ship Out (Option 5d)	22	<1	159	<1

5.13 Utilities and Energy

The existing capacities and distribution systems at the SRS for electricity, steam, water, and domestic wastewater treatment are adequate to support any of the five alternatives. Table 5-18 summarizes estimates of the annual requirements for electricity, steam, and domestic wastewater treatment for each alternative and case, and compares them to current SRS usage of these resources.

Table 5-8 lists information on water usage by alternative. The utility and energy requirements for all

Table 5-18. Estimates of annual electricity, steam, and domestic wastewater treatment

requirements
for each alternative. ,b

Alternative	Electricity Usage (megawatt hours per year)	Steam Usage (kilograms per year)c	Domestic Wastewater Treatment (liters per year)d
Current SRS Usage	659,000	1.7 billion	690 million
1. No Action			
Option 1 - Wet Storage	1,400	11.3 million	35.1 million
2. Decentralization			
Option 2a - Dry Storage	19,400	16.7 million	48.7 million
Option 2b - Wet Storage	22,400	14.4 million	50.6 million
Option 2c - Processing	56,400	19.1 million	48.7 million
3. 1992/1993 Planning Basis			
Option 3a - Dry Storage	19,400	16.7 million	48.7 million
Option 3b - Wet Storage	22,400	14.4 million	50.6 million
Option 3c - Processing	56,400	19.1 million	48.7 million
4. Regionalization - A			
Option 4a - Dry Storage	24,400	16.7 million	48.7 million
Option 4b - Wet Storage	27,400	14.4 million	50.6 million
Option 4c - Processing	67,400	16.5 million	47.6 million
Regionalization - B			
Option 4d - Dry Storage	24,400	16.7 million	48.7 million
Option 4e - Wet Storage	27,400	14.4 million	50.6 million
Option 4f - Processing	56,400	19.1 million	48.7 million
Option 4g - Ship Out	11,400	11.7 million	38.1 million
5. Centralization			
Option 5a - Dry Storage	44,400	16.7 million	67.7 million
Option 5b - Wet Storage	47,400	14.4 million	69.6 million
Option 5c - Processing	110,400	19.1 million	67.7 million
Option 5d - Ship Out	11,400	11.7 million	38.1 million

a. Source: WSRC (1994b).
b. Water requirements are shown in Table 5-8.
c. To convert kilograms to pounds, multiply by 2.2046.
d. To convert liters to gallons, multiply by 0.26418.

the alternatives represent a small percentage of current requirements. No new generation or treatment facilities would be necessary; connections to existing networks would require only short tie-in lines.

Increases in SRS fuel consumption would be minimal because overall activity on the Site would not increase due to changes in the SRS mission and the general reduction in employment levels. The overall impacts of any of the alternatives on the SRS utilities and energy resources would be minimal.

The smallest increase in demand would result from the No Action alternative, which would be similar to current spent nuclear fuel-related requirements at the SRS. The largest increases would be due to the centralization of spent nuclear fuel at the SRS (Alternative 5). Alternative 5 would result in a maximum additional electrical demand of about 110,400 megawatt-hours annually (Option 5c), and an increased steam consumption of about 19.1 million kilograms (42.1 million pounds) per year (Option 5c). Water requirements would also be greatest under this Alternative (Table 5-8). Annual withdrawals of Savannah River water for cooling purposes would reach about 310.8 million liters (82.1 million gallons) and groundwater usage for domestic and processing purposes would total approximately 69.6 million liters (18.4 million gallons). The volume of domestic wastewater requiring treatment would range from approximately 35 to 70 million liters (9 to 18 million gallons) per year. This additional water usage amounts to an increase of about 10 percent over current SRS water requirements.

Among the three management options, processing would result in the greatest increase in demand on utilities and energy in comparison to either the dry or wet storage options. In general, dry and wet storage would be similar in their requirements of these resources.

5.14 Materials and Waste Management

This section discusses potential impacts of the management of materials and wastes associated with the implementation of alternatives identified for spent nuclear fuel management. Sections 5.7 and 5.12 (Air Quality and Occupational and Public Health and Safety, respectively) discuss the impacts of hazardous and toxic materials as they relate to routine operations and accidents.

DOE has projected rates and volumes of waste and impacts of waste generation at SRS for low-level, transuranic, and high-level wastes for each of the alternatives for spent nuclear fuel management. Table 5-19 summarizes the estimated annual average and total volume of these three waste types that **each alternative would produce during a 40-year management period.** The discussion

Table 5-19. Annual average and total volume (cubic meters)[d] of radioactive wastes produced under each alternative during the 40-year interim management period.

	Low-level waste[b]		Transuranic waste		High-level waste[c]	
Alternative	Average	Total	Average	Total	Average	Total
1. No Action						
Option 1 - Wet Storage	400	16,000	17	700	0.4	4
2. Decentralization						
Option 2a - Dry Storage	400	16,000	18	720	0.4	4
Option 2b - Wet Storage	400	16,000	18	720	0.4	4
Option 2c - Processing	800	32,000	19	760	2.3	23
3. 1992/1993 Planning Basis						
Option 3a - Dry Storage	400	16,000	18	720	0.4	4
Option 3b - Wet Storage	400	16,000	18	720	0.4	4
Option 3c - Processing	750	30,000	19	760	1.7	17
4. Regionalization - A						
Option 4a - Dry Storage	400	16,000	17	700	0.4	4
Option 4b - Wet Storage	400	16,000	17	700	0.4	4
Option 4c - Processing	790	31,600	18	720	2.3	23
4. Regionalization - B						
Option 4d - Dry Storage	400	16,000	17	700	0.4	4
Option 4e - Wet Storage	400	16,000	17	700	0.4	4
Option 4f - Processing	790	31,600	18	720	2.3	23
Option 4g - Ship Out	400	4,000	18	180	0	0
5. Centralization						
Option 5a - Dry Storage	400	16,000	16	640	0	0
Option 5b - Wet Storage	400	16,000	20	800	2.3	23
Option 5c - Processing	800	32,000	20	800	2.3	23

Option 5d - Ship Out	400	4,000	18	180	0	0

a. Based on WSRC (1994b).
b. Source: WSRC (1994c).
c. Figures are for the initial 10-year period when most processing would be completed.
d. To convert cubic meters to cubic yards multiply by 1.307.

below also identifies the impacts that the waste produced by spent nuclear fuel activities would have on the existing SRS capacity to manage each waste type.

DOE has not developed estimates of low-level mixed, hazardous, or solid sanitary wastes that spent nuclear fuel management activities at the SRS could generate, although it is anticipated that these activities would produce these waste types only in limited quantities. Further, the discussions in Section 5.14.2 related to the impacts of spent fuel management wastes on the SRS waste capacities do not include considerations of wastes that will result from Site cleanup because assessments for these activities are still underway and will undergo NEPA review as part of the SRS Waste Management Environmental Impact Statement (DOE 1995).

Volume 1 of this spent nuclear fuel EIS provides information concerning the major Federal environmental laws and regulations, Executive Orders, and DOE Orders that apply to pollution prevention at the Savannah River Site. The DOE views source reduction as the first priority in its pollution prevention program, followed by an increased emphasis on recycling. Source reduction will reduce the waste management burden while eliminating the potential for future liability and cleanup. Recycling and using recycled materials will conserve resources and landfill space. Waste treatment and disposal are considered only when prevention or recycling is not possible or practical. Since creating a Savannah River Site waste minimization program (the precursor of the SRS pollution prevention program) in 1990, the amounts of wastes of all types (excluding low-level wastes, which are a by-product of environmental restoration activities) generated have decreased, with greatest reductions in hazardous and mixed wastes (Hoganson and Miles 1994).

5.14.1 Alternative Comparison

The first four alternatives would generate similar amounts of radioactive waste because the activities that produce the wastes would be similar under each of the alternatives. Most of the low-level and transuranic wastes would be generated during the first part of the 40-year management period while DOE was transferring existing inventory and renovating the Receiving Basin for Offsite Fuels and a reactor basin. The characterization and canning of the current inventory prior to placement into storage would also result in some waste generation. Once in storage, management activities would produce only small amounts of radioactive waste for the rest of the 40-year period.

The dry- and wet-storage options would both produce about 16,000 cubic meters (20,912 cubic yards) of low-level waste and between 640 cubic meters (836 cubic yards) and 800 cubic meters (1,046 cubic yards) of transuranic waste during the 40-year management period. Both options would generate small amounts of high-level waste. The processing of the existing aluminum-clad fuels and storage of the others (the third option under each alternative) would generate all three types of waste: low-level and high-level wastes in appreciably greater volumes, and transuranic waste in slightly greater volumes.

Alternative 5 (excluding the Ship Out option) could result in somewhat larger volumes of radioactive waste than the other four alternatives. However, any increase in waste would not be directly proportional to the larger amounts of fuel that would be managed on the Site, because most of the originating sites would characterize and can their fuel prior to shipment so that it could be placed directly into storage at the SRS. Therefore, the radioactive wastes produced during centralization at the Site would come from the initial fuel transfer and pool renovations and from characterizing and canning small amounts of new fuel. The processing of existing aluminum-clad fuels would produce the same types and volumes of waste as for the other alternatives.

The option for shipping the SRS inventory off the Site for regionalization or centralization elsewhere would also result in the production of some radioactive waste. This would occur during characterization and canning prior to shipment and would generate the smallest volumes of waste of any alternative action: 4,000 cubic meters (5,228 cubic yards) of low-level waste and 180 cubic meters (235 cubic yards) of transuranic waste. This waste would be produced only during the initial 10 years of the management period.

5.14.2 Impact on the SRS Waste Management Capacity

The impact of spent nuclear fuel activities on SRS waste management capacities would be minimal because the Site could accommodate the waste with existing and planned radioactive waste storage and disposal facilities. DOE would transfer high-level waste to the F/H Tank Farms for volume reduction and then to the Defense Waste Processing Facility (DWPF) for conversion into a borosilicate glass form suitable for prolonged storage. The SRS would use the Consolidated Incineration Facility, once operational, to treat the low-level waste. This facility has sufficient permitted capacity [105,500 cubic meters (137,889 cubic yards) per year] to treat the anticipated volume of these materials. However, actual through-put volume is dependent upon operational variables and waste characteristics. The F/H Effluent Treatment Facility would treat liquid low-level waste. This facility has sufficient design process capacity [598 million liters (158 million gallons) per year] to treat the anticipated volumes of these materials. DOE would manage the transuranic wastes with existing and planned storage capacity.

5.15 Accident Analysis

Operations involving the receipt, handling, processing, or storing of spent nuclear fuel would involve radioactive materials or toxic chemicals. These materials would be received, treated, stored, transferred between facilities, disposed of on the Site, and shipped off the Site. Under certain circumstances, these materials could be involved in an accident.

An accident is a series of unexpected or undesirable events initiated by equipment failure, human error, or a natural phenomenon such as severe weather, earthquake, or volcanism. These events can cause the release of either radioactive or chemically toxic materials inside a facility or to the environment.

This section summarizes analyses of possible accidents involving spent nuclear fuel operations at the SRS. To provide a perspective on potential accidents, this section summarizes various accidents associated with spent nuclear fuel activities that have occurred at the SRS (historic accidents) and reviews previous accident analyses for Site operations. This section uses the results of previous analyses as a baseline for determining the impacts for the alternatives that involve new facilities. For each alternative, this section discusses the accidents with the largest point estimates of risk (radiological impacts in terms of potential fatal cancers x frequency of the initiating event).

The facilities considered for each alternative are either existing facilities for which the approved safety analyses were used, or new facilities (WSRC 1994b) for which existing safety analysis results were substituted by evaluating the type of accident(s) that could be postulated to occur based on the projected function of the facility. Two facilities that contain very small amounts of contact-handled spent nuclear fuel, Buildings 331-M and 773-A, were not included in this analysis because accidents analyzed for the major facilities would bound the consequences of possible accidents in these two locations.

This section addresses historic accidents, facility radiological accidents, chemical hazard accidents, and secondary impacts. Section 5.11 addresses onsite transportation accidents.

5.15.1 Historic Accidents at the Savannah River Site

Impacts from accidents can involve fatalities, injuries, or illness. Fatalities can be prompt (immediate) such as in construction accidents or latent (delayed) such as an increase in latent fatal cancers due to radiation exposure. Section 5.12 addresses worker injuries, illnesses, and the potential for increased cancer risk anticipated from normal operations of the facilities. Nonradiation accidents have dominated impacts to workers at the SRS (Durant et al. 1987); impacts to the public from historic SRS accidents have been negligible.

The SRS has maintained an operational event data base on its facilities since the 1950s. This data base currently contains approximately 450,000 entries including data on the Receiving Basin for Offsite Fuel, the principal wet storage pool facility at the SRS; and both F-and H-Area Canyons. For this EIS, DOE reviewed the data base to identify historic spent nuclear fuel-related accidents at these facilities. Fuel cutting events, fuel handling events, and various liquid releases related to spent nuclear fuel management over the 40-year operating history of the SRS were examined. The purpose of the data base review was to provide an historic perspective on the types of accidents that have occurred at the SRS. Events representative of fuel failures include higher than expected contamination levels in fuel storage basin water and evidence of fuel canister cracking at a weld. Fuel handling incidents were due in large part to crane operator errors or crane and handling equipment failures. The data base also includes reports of incorrect fuel cropping, where the active region of fuel was exposed under water. These historical events provided a basis for the selection of representative accidents covering the spectrum of spent nuclear fuel management activities. No significant offsite impacts have resulted from these historic occurrences.

5.15.2 Potential Facility Accidents

The SRS spent nuclear fuel alternatives have the potential for radiological accidents (see Attachment A, Table A-2) that could affect the health and safety of workers and the public. The concerns and characteristics that are common to these accidents would be common regardless of whether the cause were a natural phenomenon or human error. For health effects to occur, an accident must allow a release of hazardous material to, or an increase in radiation levels in, the facility or the environment. The released material must be transported to locations frequented by humans. The quantities of hazardous materials that reach locations where people are and the ways they interact with people are important factors in the determination of health effects.

A number of studies have investigated the ways in which radioactivity reaches humans, how the body absorbs and retains it, and the resulting health effects. The International Commission on Radiological Protection has made specific recommendations for estimating these health effects (ICRP 1991). This organization is the recognized body for establishing standards for the protection of workers and the public from the effects of radiation exposure. Health effects include acute damage (up to and including death) and latent effects, including cancers and genetic damage. An SRS-developed computer code, AXAIR89Q, estimates potential radiation doses to maximally exposed individuals or population groups from accidental releases of radionuclides.

The AXAIR89Q code is a highly automated site-specific environmental dispersion and dosimetry code for postulated airborne releases. The environmental dispersion models used are based on NRC Regulatory Guide 1.145 (NRC 1983). The exposure pathways considered in the AXAIR89Q code include inhalation of radionuclides and gamma irradiation from the radioactive plume.

Doses from the inhalation of radionuclides in air depend on the amount of radionuclides released; the dispersion factor; the physical, chemical, and radiological characteristics of the radionuclides; and various biological parameters such as breathing rate and biological half-life. The AXAIR89Q code uses a conservative breathing rate of 12,000 cubic meters (424,000 cubic feet) per year for adults. The dose commitment factors used in the environmental dosimetry code, as described in the following section, are from Internal Dose Conversion Factors for Calculation of Dose to the Public (DOE 1988).

External gamma radiation doses from the traveling plume depend on the spatial distribution of the radionuclides in the air, the energy of the radiation, and the extent of shielding. The AXAIR89Q code takes no credit for shielding in calculating doses. The code calculates gamma doses using a nonuniform Gaussian model, which has more realistic modeling than doses from the conventional uniform semi-infinite plume model.

In addition to using the worst sector, 99.5 percentile meteorology, conservative breathing rates, and taking no credit for shielding, the AXAIR89Q code also takes no credit for the probable plume rise from stack releases. Therefore, the offsite maximum individual doses calculated by AXAIR89Q provide conservative bounding estimates of radiological consequences to exposed individuals and populations from postulated accidental atmospheric releases.

AXAIR89Q has been validated for compliance to accepted standards for such software. Attachment A, Accident Analysis, discusses AXAIR89Q and its predecessor, AXAIR. When used in conjunction with models for predicting health effects, the results from AXAIR89Q can be compared with other site-specific codes such as RSAC-5, because both codes provide relative radionuclide concentrations based on the guidance provided in NRC Regulatory Guide 1.145.

This section summarizes the potential for radiological accidents and their consequences for the cases under each alternative. Attachment A describes the methodology and assumptions used in the assessment; describes radiological accident scenarios in more detail; provides source terms and references used to estimate the doses and impacts for each alternative and case; and includes scaling factors that the DOE decisionmaker can apply to the source term or dose for each facility associated with a case.

DOE assessed the potential impacts from a selected spectrum of radiological release accidents, ranging from low (1 x 10-6 event per year) to high (more than 1 event per year) frequencies of occurrence, along with the associated impacts (doses and potential latent fatal cancers) that could result. The accidents used as references are attributed to individual facilities based on their functions and processes (see Attachment A, Table A-3), not to specific cases or alternatives. This enables a comparison of alternatives depending on which facilities support a specific case or alternative. Figure 5-1 is a flowchart for the preparation of accident analysis information. No new analyses occurred because existing documentation adequately supports a quantitative or qualitative estimation of potential impacts, as required by the National Environmental Policy Act of 1969. The assessment of postulated radiological accidents associated with spent nuclear fuel at the SRS indicates that the highest point estimate of risk to the public within 80 kilometers (50 miles) of the Site would be 1.4 x 10-3 latent fatal cancer per year. The estimated dose to the same population from all causes, including natural background sources, would be about 19,000 person-rem per year (DOE 1990), which could cause about nine latent fatal cancers per year in the same population. For perspective, natural background radiation sources would result in approximately 6,000 times the risk associated with the largest consequence accident postulated in this EIS for the various spent nuclear fuel management alternatives.

DOE did not quantitatively analyze the potential health effects for SRS workers less than 100 meters (328 feet) from radiological accidents. Computer codes used to calculate radiological doses can experience potentially large errors as a source disperses throughout a building. However, DOE did carry out a qualitative evaluation of the potential radiological effects to SRS workers in the immediate vicinity of an accident related to spent fuel management. DOE estimates that the consequences of an accident for the most part would result in higher than normal radiation doses. However, no fatalities would occur except in the event of an inadvertent criticality in FB-Line, where up to four fatalities may result. This evaluation is discussed in more detail in Section A.2.6.2 of Attachment A.

5.15.2.1 Alternative 1 - No Action. This alternative identifies the minimum actions deemed necessary for continued safe and secure management of spent nuclear fuel at the SRS. As explained in Chapter 3, this is not a status quo condition. Spent nuclear fuel would be maintained close to defueling or current storage locations with minimal facility upgrade or equipment replacement. Only local transport would occur. SRS activities required to safely store spent nuclear fuel would continue. This alternative would require SRS to place corroded and pitted fuel elements in cans to minimize spread of material into the pool. DOE estimated potential radiological accident impacts that could occur under this alternative using existing DOE-approved safety analyses for the interim wet storage of Figure 5-1. Accident analysis process. spent nuclear fuel at SRS facilities. As indicated in Attachment A, Table A-3, the facilities required under this alternative would consist of existing facilities, including necessary upgrades to support safe interim wet storage. In addition, Attachment A, Table A-4, provides a reference accident spectrum associated with these facilities for this alternative. Attachment A, Table A-2, lists the references for the source terms considered in analyzing potential accidents under this alternative, as well as their estimated frequencies. Table 5-20 lists the accident scenario with the highest point estimates of risk to the general public. Table 5-21 compares the potential radiological accidents and health effects of the interim wet storage (Option 1) of spent nuclear fuel for the No Action alternative.

Table 5-20. Highest point estimates of risk among receptor groups (Option 1).

	Receptor Groups	
	Maximally Exposed Offsite Individual	Population to 80 kilometers
Overall Point Estimate of Risk[a]	1.6x10-7 (Fuel Assembly Breach)	1.4x10-3 (Fuel Assembly Breach)

a. Units of latent fatal cancers per year.

5.15.2.2 Alternative 2 - Decentralization. Accident assessments considered for this

alternative include those considered for the No Action alternative for wet storage (Option 2b) plus assessments for the dry storage (Option 2a) of spent nuclear fuel and for the processing of spent fuel (Option 2c). Option 2c (processing) assumes the use of existing facilities to dissolve, separate, and further stabilize spent nuclear fuel. For cases that include some treatment (e.g., canning) of spent nuclear fuel, such treatment is referred to as "stabilization," not processing. The amount of fuel of various types to be considered would include those quantities from the production reactors, existing research fuel, foreign research reactor fuel, and fuel transported for safety or research activities.

5.15.2.2.1 Option 2a - Dry Storage - DOE estimated potential radiological accident

impacts that could occur in this case using existing DOE-approved safety analysis reports submitted to DOE by Westinghouse Savannah River Company for vault storage of special nuclear material from existing facilities.

DOE has not incorporated the technology to support interim dry storage of spent nuclear fuel at the SRS. To provide a basis for evaluating the potential impacts from this alternative case, this assessment used data from existing safety analyses for special nuclear material storage facilities and extrapolated these data to apply to spent nuclear fuel. DOE also considered radiological accidents associated with wet storage, at least in the near term, because the spent nuclear fuel is currently in wet storage. Similarly, this assessment includes fuel handling accidents throughout the transition phase (i.e., until fuel is in interim dry storage). As indicated in Attachment A, Table A-4,

Table 5-21. Radioactive release accidents and health effects for spent nuclear fuel alternatives. ,b

			Potential Fatal Cancers				Point Estimate of Risk[c]			
Alternative (by case)	Accident Scenario	Frequency (per year)	Maximally exposed offsite individual[d]	Population to 80 kilometers[d]	Worker[e]	Colocated Worker[e]	Maximally exposed offsite individual	Population to 80 kilometers[f]	Worker	Colocated Worker
1. No Action										
Option 1 Wet Storage	A1 Fuel Assembly	1.6x10-1	1.0x10-6							

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8.5x10-3         (a)       4.8x10-6    1.6x10-7    1.4x10-3         (a)      7.7x10-7
                                  Breach
                               A4 Material Release                      2.4x10-3     3.0x10-6
2.5x10-2         (a)       2.0x10-5    7.2x10-9    6.0x10-5         (a)      4.8x10-8
                                  (Adjacent Facility)
                               A5 Criticality in Water                  3.1x10-3     1.5x10-6
4.4x10-3         (a)       5.6x10-5    4.7x10-9    1.4x10-5         (a)      1.7x10-7
                               A7 Spill/Liquid                          2.0x10-4     2.7x10-6
9.0x10-3         (a)       1.1x10-6    5.4x10-10   1.8x10-6         (a)      2.2x10-10
                                  Discharge (external)
                               A8 Spill/Liquid                          1.1x10-1     1.2x10-13
1.0x10-9         (a)       8.0x10-15   1.3x10-14   1.1x10-10        (a)      8.8x10-16
                                  Discharge (internal)
2.  Decentralization
Option 2a Dry                  A1 Fuel Assembly                         1.6x10-1     1.0x10-6
8.5x10-3         (a)       4.8x10-6    1.6x10-7    1.4x10-3         (a)      7.7x10-7
Storage                           Breach
                               A3 Material Release                      1.4x10-3     1.1x10-9
3.5x10-6         (a)       (b)         1.5x10-12   4.9x10-9         (a)      (b)
                                  (Dry Vault)
                               A4 Material Release                      2.4x10-3     3.0x10-6
2.5x10-2         (a)       2.0x10-5    7.2x10-9    6.0x10-5         (a)      4.8x10-8
                                  (Adjacent Facility)
                               A5 Criticality in Water                  3.1x10-3     1.5x10-6
4.4x10-3         (a)       5.6x10-5    4.7x10-9    1.4x10-5         (a)      1.7x10-7
                               A7 Spill/Liquid                          2.0x10-4     2.7x10-6
9.0x10-3         (a)       1.1x10-6    5.4x10-10   1.8x10-6         (a)      2.2x10-10
                                  Discharge (external)
                               A8 Spill/Liquid                          1.1x10-1     1.2x10-13
1.0x10-9         (a)       8.0x10-15   1.3x10-14   1.1x10-10        (a)      8.8x10-16
                                  Discharge (internal)
Option 2b Wet                  A1 Fuel Assembly                         1.6x10-1     1.0x10-6
8.5x10-3         (a)       4.8x10-6    1.6x10-7    1.4x10-3         (a)      7.7x10-7
Storage                           Breach
                               A4 Material Release                      2.4x10-3     3.0x10-6
2.5x10-2         (a)       2.0x10-5    7.2x10-9    6.0x10-5         (a)      4.8x10-8
                                  (Adjacent Facility)
                               A5 Criticality in Water                  3.1x10-3     1.5x10-6
4.4x10-3         (a)       5.6x10-5    4.7x10-9    1.4x10-5         (a)      1.7x10-7
                               A7 Spill/Liquid                          2.0x10-4     2.7x10-6
9.0x10-3         (a)       1.1x10-6    5.4x10-10   1.8x10-6         (a)      2.2x10-10
                                  Discharge (external)
                               A8 Spill/Liquid                          1.1x10-1     8.2x10-13
1.0x10-9         (a)       8.0x10-15   1.3x10-14   1.1x10-10        (a)      8.8x10-16
                                  Discharge (internal)
Option 2c Processing           A1 Fuel Assembly                         1.6x10-1     1.0x10-6
8.5x10-3         (a)       4.8x10-6    1.6x10-7    1.4x10-3         (a)      7.7x10-7
                                  Breach
                               A2 Material Release                      2.6x10-1     3.4x10-8
2.6x10-4         (a)       3.6x10-8    8.9x10-9    6.8x10-5         (a)      9.4x10-9
                                  (Processing)
Option 2c                      A3 Material Release                      1.4x10-3     1.1x10-9
3.5x10-6         (a)       (b)         1.5x10-12   4.9x10-9         (a)      (b)
(continued)                       (Dry Vault)
                               A4 Material Release                      2.4x10-3     3.0x10-6
2.5x10-2         (a)       2.0x10-5    7.2x10-9    6.0x10-5         (a)      4.8x10-8
                                  (Adjacent Facility)
                               A5 Criticality in Water                  3.1x10-3     1.5x10-6
4.4x10-3         (a)       5.6x10-5    4.7x10-9    1.4x10-5         (a)      1.7x10-7
                               A6 Criticality in                        1.4x10-4     3.5x10-6
4.3x10-3         (a)       1.0x10-4    4.9x10-10   6.0x10-7         (a)      1.4x10-8
                                  Processing
                               A7 Spill/Liquid                          2.0x10-4     2.7x10-6
9.0x10-3         (a)       1.1x10-6    5.4x10-10   1.8x10-6         (a)      2.2x10-10
                                  Discharge (external)
                               A8 Spill/Liquid                          1.1x10-3     1.2x10-13
1.0x10-9         (a)       8.0x10-15   1.3x10-14   1.1x10-10        (a)      8.8x10-16
                                  Discharge (internal)
3.  1992/1993 Planning Basis
Option 3a Dry                  Same as Option 2a for Decentralization
Storage
Option 3b Wet                  Same as Option 2b for Decentralization
Storage
Option 3c Processing           Same as Option 2c for Decentralization
4.  Regionalization - A
Option 4a Dry                  Same as Option 2a for Decentralization
Storage
Option 4b Wet                  Same as Option 2b for Decentralization
Storage
Option 4c Processing           Same as Option 2c for Decentralization
4.  Regionalization - B
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Option 4d Dry Storage	Same as Option 2a for Decentralization
Option 4e Wet Storage	Same as Option 2b for Decentralization
Option 4f Processing	Same as Option 2c for Decentralization
Option 4g Shipping Out	Same as Option 1 for No Action
5. Centralization	
Option 5a Dry Storage	Same as Option 2a for Decentralization
Option 5b Wet Storage	Same as Option 2b for Decentralization
Option 5c Processing	Same as Option 2c for Decentralization
Option 5d Shipping Out	Same as Option 1 No Action

a. The safety analysis reports from which information was extracted for these accidents were written before the issuance of DOE Order 5480.23; previous Orders did not require the inclusion of workers.
b. The safety analysis reports from which information was extracted for these accidents were written before the issuance of DOE Order 5480.23; previous Orders did not require the inclusion of colocated workers.
c. Units for point estimates of risk are given in potential latent fatal cancers per year.
d. ICRP 60 risk factor for the general public (5.0 x 10-4 fatal cancer per year) was used to determine potential latent fatal cancers.
e. ICRP 60 risk factor for workers (4.0 x 10-4 fatal cancer per year) was used to determine potential latent fatal cancers.

the facilities required under this alternative would consist of existing and new facilities necessary to support the safe handling, stabilization, and dry storage of spent nuclear fuel. In addition, Table A-4 identifies a potential accident spectrum associated with these facilities for this case. Attachment A, Table A-2, lists the references for the source terms considered in analyzing potential accidents under this alternative case, as well as the estimated frequency of occurrence for each accident. Table 5-21 lists the potential radiological accidents and health effects associated with dry storage of spent nuclear fuel for the Decentralization alternative. For the transition period of wet to dry storage, Table 5-22 lists the accident scenario with the highest overall point estimate of risk to the general public.

Table 5-22 lists the accident scenario with the highest point estimate of risk (after transition) to the general public when the fuel had been moved from wet storage (after approximately 15 years) and **placed in interim dry storage.** This indicates a substantial reduction in risk (more than six orders of magnitude) when fuel handling events are no longer potential accident initiators.

Table 5-22. Highest point estimates of risk among receptor groups (Option 2a).

	Receptor Groups	
	Maximally Exposed Offsite Individual	Population to 80 kilometers
Overall Point Estimate of Riska	1.6x10-7 (Fuel Assembly Breach)	1.4x10-3 (Fuel Assembly Breach)
Transitioned to Dry Storage Point Estimate of Riska	1.5x10-12 (Dry Vault Material Release)	4.9x10-9 (Dry Vault Material Release)

a. Units of latent fatal cancers per year.

5.15.2.2.2 Option 2b - Wet Storage - DOE estimated potential radiological accident

impacts that could occur under this case using existing DOE-approved safety analysis reports and amendments submitted to DOE by Westinghouse Savannah River Company for existing wet storage facilities.

As indicated in Attachment A, Table A-4, the facilities (modules as defined in the WSRC 1994b and Figure 3-2) would consist of existing facilities and specific upgrades necessary to support safe interim wet storage. In addition, Table A-4 identifies the reference accident spectrum associated with these facilities for this option. Attachment A, Table A-2, lists the references for the source terms considered in analyzing potential accidents under this alternative option, as well as the estimated frequency of occurrence for each accident. Table 5-21 lists the radiological accidents and consequences of the wet storage (Option 2b) of spent nuclear fuel for the Decentralization alternative.

Table 5-23 lists the accident scenario with the highest point estimate of risk to the general public. For wet pool storage options, there are no transition phases.

Table 5-23. Highest point estimates of risk among receptor groups (Option 2b).

	Receptor Groups	
	Maximally Exposed Offsite Individual	Population to 80 kilometers
Overall Point Estimate of Risk[a]	1.6x10-7 (Fuel Assembly Breach)	1.4x10-3 (Fuel Assembly Breach)

a. Units of latent fatal cancers per year.

5.15.2.2.3 Option 2c - Processing and Storage - Processing for the SRS is defined

as the operation of the separations facilities in F- or H-Areas. The H-Area facilities were designed to recover uranium and plutonium from spent production reactor fuel, and the F-Area facilities were designed to recover plutonium.

DOE estimated potential radiological accident impacts that could occur under this option using existing DOE-approved safety analysis reports submitted to DOE by Westinghouse Savannah River Company for processes and for vault storage of special nuclear material from existing facilities. DOE also considered radiological accidents associated with wet storage, because the spent nuclear fuel is currently in wet storage. Similarly, it included fuel handling accidents throughout the processing phase (i.e., until special nuclear material is in interim dry storage). As indicated in Attachment A, Table A-4, the facilities required under this option would consist of existing and new facilities necessary to support safe handling and processing of spent nuclear fuel into special nuclear material for dry storage. In addition, Table A-4 identifies the reference accident spectrum associated with these facilities for this case. Attachment A, Table A-2, lists the references for the source terms considered in analyzing potential accidents under this alternative case, as well as the estimated frequency of occurrence for each accident. Table 5-21 lists the radiological release accidents and health effects for the processing of spent nuclear fuel to special nuclear material for the Decentralization alternative.

Table 5-24 lists the accident scenario with the highest overall point estimate of risk to the general **public from the transition period of wet spent fuel storage into processing for special nuclear material.**

When the fuel had been processed from wet storage to special nuclear material and placed in its interim dry storage, Table 5-24 lists the accident scenario with the highest point estimate of risk after transition to the general public. This indicates a substantial reduction in risk (more than six orders of magnitude) when fuel handling events and processing events are no longer potential accident initiators.

Table 5-24. Highest point estimates of risk among receptor groups (Option 2c).

	Receptor Groups	
	Maximally Exposed Offsite Individual	Population to 80 kilometers
Overall Point Estimate of Risk[a]	1.6x10-7 (Fuel Assembly Breach)	1.4x10-3 (Fuel Assembly Breach)
Transitioned to Dry Storage Point Estimate of Risk[a]	1.5x10-12 (Dry Vault Material Release)	4.9x10-9 (Dry Vault Material Release)

a. Units of latent fatal cancers per year.

For this option, DOE assumes it could not process some fuel clad in stainless steel or zirconium into special nuclear material and, therefore, would dry-store it as fuel. The technology for dry storage of nonaluminum-clad fuel has been demonstrated and is assumed to pose no greater risk than monitored dry storage of special nuclear material.

5.15.2.3 Alternative 3 - 1992/1993 Planning Basis. Because this alternative would be

consistent with the status quo at the SRS, existing documents contain sufficient information to examine its accident analysis impacts. The SRS would continue to receive the spent nuclear fuel designated for the Site, and DOE would complete facilities already planned to accommodate the existing inventory and the spent nuclear fuel receipts. This alternative would require the same facilities already used to support the cases discussed in the Section 5.15.2.2. The major difference would be the amount of fuel ultimately stored because this alternative assumes the continued receipt of fuel beyond that shipped to the SRS under the Decentralization alternative.

5.15.2.3.1 Option 3a - Dry Storage - DOE estimated potential radiological accident

impacts that could occur under this case using existing DOE-approved safety analysis reports for vault storage from existing facilities and the study discussed for Option 2a. DOE also considered radiological accidents associated with wet storage, at least in the near term, because the spent nuclear fuel is currently in wet storage. Similarly, it included fuel handling accidents throughout the transition phase (i.e., until the fuel is in interim dry storage). As indicated in Attachment A, Table A-4, the facilities required under this option would consist of existing and new facilities necessary to support the safe handling and stabilization of spent nuclear fuel for dry storage. In addition, Table A-4 identifies the reference accident spectrum associated with these facilities for this case. Attachment A, Table A-2, lists the authorization basis references for the source terms considered in analyzing potential accidents under this option, as well as the estimated frequency of occurrence for each accident. Table 5-21 lists the radiological release accidents and health effects for the dry storage of spent nuclear fuel for the 1992/1993 Planning Basis alternative. For the entire period, the accident scenarios with the highest point estimates of risk to the general public would be the same as those for Option 2a, as listed in Table 5-22.

5.15.2.3.2 Option 3b - Wet Storage - DOE estimated potential radiological accident

impacts that could occur under this case using existing DOE-approved safety analysis reports and from amendments submitted to DOE by Westinghouse Savannah River Company for wet storage for existing facilities. As indicated in Attachment A, Table A-4, the facilities required under this option would consist of existing facilities and upgrades necessary to support safe interim wet storage. In addition, Table A-4 identifies the reference accident spectrum associated with these facilities for this option. Attachment A, Table A-2, lists the references for the source terms considered in analyzing potential accidents under this option, as well as the estimated frequency of occurrence for each accident. Table 5-21 lists the radiological release accidents and health effects of the wet storage (Option 3b) of spent nuclear fuel for the 1992/1993 Planning Basis alternative. The accident scenario with the highest point estimate of risk to the general public would be the same as that for Option 2b, as listed in Table 5-23.

5.15.2.3.3 Option 3c - Processing and Storage.

Table 5-21 lists the radioactive **release accidents and health effects for the processing of spent nuclear fuel for this option.** After processing is complete, the accident scenario with the highest point estimate of risk would be associated with the storage of special nuclear materials, as discussed for Option 2c and listed in

Table 5-24.

5.15.2.4 Alternative 4 - Regionalization. This alternative comprises Regionalization A and

Regionalization B subalternatives. Under the Regionalization A subalternative (Options 4a, 4b, and 4c), the SRS would receive all aluminum-clad fuel from the other sites considered in this EIS and would transfer its existing inventory of stainless steel- and Zircaloy-clad fuel to other DOE sites, as appropriate. These proposed activities would reflect current and past activities, so sufficient information and analyses are available to enable the scaling or other extrapolation of radiological accident impacts. The total amount of spent nuclear fuel to be managed under Regionalization A would be slightly less than that for Alternatives 2 and 3; the decisionmaker could use this amount to adjust the estimated point estimate of risk by the use of an appropriate adjustment (scaling) factor, as discussed in Attachment A, Section A.2.9.

Under the Regionalization B subalternative (Options 4d, 4e, 4f, and 4g), the SRS would receive all existing and new spent nuclear fuel east of the Mississippi River. The decisionmaker could use the change in spent nuclear fuel inventories to adjust the estimated point estimate of risk by the use of an appropriate adjustment (scaling) factor, as discussed in Attachment A, Section A.2.9. For the purposes of this evaluation, Option 4g (Section 5.15.2.4.7) assumes that DOE would ship all fuel off the Site to the Oak Ridge Reservation.

5.15.2.4.1 Option 4a - Dry Storage - This case is similar to Option 2a, with the

exception of the quantity and type of fuel to be stored. As with Option 2a, this assessment evaluated existing analyses; the point estimates of risk are the same as those for Option 2a.

5.15.2.4.2 Option 4b - Wet Storage - This case is similar to Option 2b, with the

exception of a slightly smaller quantity of fuel to be stored. As with Option 2b, this assessment evaluated existing analyses, and the point estimates of risk are the same as those for Option 2b.

5.15.2.4.3 Option 4c - Processing and Storage - For this option, the accident

analysis evaluation is similar to Option 2c. DOE assumes that it could process spent nuclear fuel associated with regionalization at SRS with existing facilities, because they are designed to process aluminum-clad fuel. However, the small amount of aluminum-clad fuel received after major processing options are completed would be placed in wet storage.

5.15.2.4.4 Option 4d - Dry Storage - The accident analysis evaluation for this option

is similar to that for Option 2a, with the exception of the increased inventories and types of fuel to be stored.

5.15.2.4.5 Option 4e - Wet Storage - The accident analysis evaluation for this option

is similar to that for Option 2b, with the exception of the increased inventories and types of fuel to be stored.

5.15.2.4.6 Option 4f - Processing and Storage - For this option, the accident

analysis evaluation is similar to Option 2c. DOE assumes that it could process all the current SRS aluminum-clad spent nuclear fuel with existing facilities. However, all receipts of spent nuclear fuel will be placed in dry storage as discussed for Option 4d.

5.15.2.4.7 Option 4g - Shipping Off Site - This option assumes that DOE would

characterize the fuel and ship it all off the Site. Thus, the potential radiological accidents considered are the same as those for Alternative 1.

5.15.2.5 Alternative 5 - Centralization. This alternative for the SRS would involve fuel

types and new facilities beyond those considered for any other alternative. For instance, under this alternative, the SRS would receive spent nuclear fuel from the U.S. Navy. One of the new facilities that would be necessary to support this type of spent nuclear fuel is the Expended Core Facility (ECF). Volume 1, Appendix D, includes a detailed accident analyses for this proposed facility using SRS-specific parameters.

This alternative would bound the maximum number of spent nuclear fuel-related accident scenarios that DOE could expect at the SRS, due to the number of new facilities at the Site that would have to accommodate the diversity and the increased amount of the fuel to be managed. The decisionmaker could use this maximum amount of spent nuclear fuel to adjust the estimated risk by the use of an appropriate scaling factor, as discussed in Attachment A, Section A.2.9. For the purposes of this evaluation, Option 5d (Section 5.15.2.5.4) assumes that DOE would ship all fuel off the Site to another DOE facility.

5.15.2.5.1 Option 5a - Dry Storage - The major difference in dry storage facilities

between this alternative and the others would be the addition of a facility for Naval spent nuclear fuels and the large quantity of spent fuel shipped to the SRS from the Hanford Site. DOE estimated potential radiological accident impacts that could occur under this option using DOE-approved safety analysis reports submitted to DOE by Westinghouse Savannah River Company for vault storage in existing facilities at the SRS and the study discussed for Option 2a. In addition, DOE considered radiological accidents associated with wet storage, at least in the near term, because the SRS spent nuclear fuel is currently in wet storage. Similarly, it included fuel handling accidents throughout the transition phase (i.e., until fuel is in interim dry storage). As indicated in Attachment A, Table A-4, the facilities required under this option would consist of existing and new facilities necessary to support the safe handling and stabilization of spent nuclear fuel for dry storage. In addition, Table A-4 identifies the reference accident spectrum associated with these facilities for this case. Attachment A, Table A-2, lists the references for the source terms considered in analyzing potential accidents under this option, as well as the estimated frequency of occurrence for each accident. Table 5-21 compares the radiological release accidents and health effects for the dry storage of spent **nuclear fuel for the Centralization alternative.** From the transition period of wet to dry storage, the accident scenario with the highest point estimate of risk to the general public would be the same as that for Option 2a, as listed in Table 5-22. When the fuel had been moved from wet storage (after approximately 25 years) and placed in interim dry storage, the accident scenario with the highest point estimate of risk to the population would be the same as the Option 2a dry storage phase.

5.15.2.5.2 Option 5b - Wet Storage - The accident analysis evaluation for this option

is similar to that for Option 2b, with the exception of the amount and type of fuel to be stored.

5.15.2.5.3 Option 5c - Processing and Storage - For this option, the accident

analysis evaluation is similar to Option 2c. DOE assumes that it could process the current SRS aluminum-clad spent nuclear fuel with existing facilities. However, the SRS would place all receipts of fuel in dry storage, as discussed for Option 5a.

5.15.2.5.4 Option 5d - Shipping Off Site - This option assumes that DOE would

perform the characterization of the fuel at the SRS, and then would ship all fuel off the Site. Thus, the potential radiological accidents considered are the same as those for the No Action alternative.

5.15.3 Chemical Hazard Evaluation

For toxic chemicals, several government agencies recommend the quantification of health effects as threshold values of concentrations in air or water that cause short-term effects. The long-term health consequences of human exposure to toxic chemicals are not as well understood as those for radiation. Thus, the potential health effects from toxic chemicals are more subjective than those from radioactive materials.

This section provides a quantitative discussion for an analyzed chemical accident at the Receiving Basin for Offsite Fuel facility and qualitative discussions addressing chemical hazards for each of the other existing SRS facilities involved in the receipt, processing, transport, or storage of spent nuclear fuel.

5.15.3.1 Receiving Basin for Offsite Fuel. The maximum reasonably foreseeable chemical

hazard accident for the Receiving Basin for Offsite Fuel would involve the release of nitrogen dioxide vapor following the complete reaction of a drum of target cleaning solution (13.4 percent nitric acid) with sodium nitrite (WSRC 1993b). The initiator for this accident is a leak from a storage tank into the target cleaning solution and involves multiple failures or maloperations with an accident probability comparable to that of a natural phenomena accident. Table 5-25 shows the concentration of nitrogen dioxide vapor that an individual at the SRS boundary and a maximally exposed colocated worker could receive.

Table 5-25. Results of analyzed chemical accident.

Receptor Group	Frequency (per year)	NO2 Concentration (mg/m3)
Maximally Exposed Offsite Individual	1.0 x 10-3	0.083
Colocated Worker	1.0 x 10-3	0.64

To determine the potential health effects from this bounding chemical accident scenario, this assessment was to compare the resulting airborne concentrations of nitrogen dioxide at various receptor distances against Emergency Response Planning Guideline (ERPG) values, where available. Because there were no ERPG values available for nitrogen dioxide, the assessment substituted other chemical toxicity values as follows:

- For Emergency Response Planning Guideline 1, the assessment substituted threshold limit values/time-weighted average (TLV/TWA) values (ACGIH 1987). The time-weighted average is the average concentration for a normal 8-hour workday and a 40-hour workweek from which nearly all workers could receive repeated exposure, day-after-day, without adverse effect.
- For Emergency Response Planning Guideline 2, the assessment substituted level of concern (LOC) values [equal to 0.1 of the immediately dangerous to life or health (IDLH) value; - see below]. The level of concern value is the concentration of a hazardous substance in the air above which there could be serious irreversible health effects or death as a result of a single exposure for a relatively short period of time (EPA 1987).
- For Emergency Response Planning Guideline 3, the assessment substituted immediately dangerous to life or health values. This value is the maximum concentration from which a person could escape within 30 minutes without a respirator and without experiencing any impairment of escape or irreversible side effects (NIOSH 1990).

These values as they apply to nitrogen dioxide are as follows:

- Time-weighted average value = 5.6 milligrams per cubic meter
- Level of concern value = 9.4 milligrams per cubic meter
- Immediately dangerous to life or health value = 94.0 milligrams per cubic meter

5.15.3.2 Reactor Basins. There are no postulated chemical accidents for the reactor basins that would cause an impact to an individual at the SRS boundary or a colocated worker.

5.15.3.3 H-Area. There are no postulated chemical accidents for the H-Area Canyon that would cause an impact to an individual at the SRS boundary or a colocated worker. DOE has performed an accident analysis for the H-Area Canyon facility workers that indicates the existence of potential injuries due to chemical contamination or exposure to hazardous vapors at or above the level of concern exposure limit (Du Pont 1983a). The analysis does not project exposure to hazardous vapors at or above the immediate danger to life and health level to occur.

The probability that a worker could be accidentally exposed to any of the hazardous liquids identified in Attachment A, Table A-14, is bounded by a frequency of 2.8 x 100 per year (Du Pont 1983a). The most likely injury is an acid burn to the skin.

The probability for exposure to hazardous vapors at or above the level of concern exposure limit is 8.5 x 10-1 per year (Du Pont 1983a). The potential for chemical uptakes and for illness would depend on the safety measures taken before the exposure, the duration of the exposure, and the mitigating actions taken after the exposure.

5.15.3.4 F-Area. There are no postulated chemical accidents for the F-Area Canyon that would cause an impact to an individual at the SRS boundary or a colocated worker. DOE has performed an accident analysis for the F-Area Canyon facility workers that indicates the existence of potential injuries due to chemical contamination or exposure to hazardous vapors at or above the level of concern exposure limit (Du Pont 1983b). The analysis does not project exposure to hazardous vapors at or above the immediate danger to life and health level to occur.

The probability that a worker could be accidentally exposed to any one of the hazardous liquids identified in Attachment A, Table A-15, is bounded by a frequency of 1.2 x 100 per year (Du Pont 1983b). The most likely injury is an acid burn to the skin.

The probability for exposure to hazardous vapors at or above the level of concern exposure limit is 3.2 x 10-1 per year (Du Pont 1983b). The potential for chemical uptakes and for illness would depend on the safety measures taken before the exposure, the duration of the exposure, and the mitigating actions taken after the exposure.

5.15.4 Secondary Impacts

The primary focus of the accident analysis is to determine the magnitude of the consequences of postulated accident scenarios on public and worker health and safety. However, DOE recognizes that chemical and radiological accidents can also adversely affect the surrounding environment (i.e., secondary impacts). Accordingly, DOE has qualitatively evaluated each of the eight radiological accident scenarios considered in this analysis for potential secondary impacts. The following paragraphs discuss the results of the evaluation, and Table 5-26 summarizes expected secondary impacts for each accident scenario.

5.15.4.1 Biotic Resources. With the exception of a direct discharge of disassembly basin water to an onsite stream, DOE does not expect radiological contamination resulting from any of the analyzed accidents to reach any onsite or offsite surface water. DOE previously evaluated the case of a direct discharge of disassembly basin water (DOE 1990) and believes that impacts on biotic resources would be minor. Therefore, the impacts on aquatic biota from any of the accident scenarios would be minor. Small areas of minor surface contamination likely would be outside the industrialized area of a postulated accident. Terrestrial biota in or near the contaminated area would be exposed to small quantities of radioactive materials and ionizing radiation until the affected area could be decontaminated. DOE believes that the impacts on biotic resources from this exposure would be minor.

5.15.4.2 Water Resources. DOE expects no adverse impacts on water quality from any of the postulated accident scenarios. Accident A7 (External Spill/Liquid Discharge) would be expected to have the most significant impact. With the exception of the reactor disassembly basins, the location and configuration of existing or potential facilities would prevent a direct release of radionuclide-contaminated water to surface water. However, contamination of the surface aquifer in the area of the release would be likely. The processes governing the slow plume movement and attenuation of contaminants described in Section 5.8 would prevent the contamination from reaching surface- or groundwater resources. Similarly, radionuclide contamination of onsite or offsite drinking

Table 5-26. Qualitative summary of expected secondary impacts.

		Environmental or social factor							
Accident Scenario	Accident Description	Biotic Resources	Water Resources	Endangered Species	Land Use	Economic Impacts	National Defense	Environmental Contamination	Treaty Rights
A1	Fuel assembly breach	No adverse effects on biota expected.	No adverse effects expected to surface or groundwater resources.	No impacts expected. No irreversible impacts.	No change expected.	Limited economic impacts are expected. Any required cleanup could be handled with existing workforce.	No effect.	Local contamination expected around site of the accident. Minor contamination outside the immediate facility area unlikely to require cleanup of more than 10 acres.	No impact to Native American or public lands expected.
A2	Material release (processing)	Same as A1.	Same as A1.	Same as A1.	Same as A1.	Same as A1.	Same as A1.	Same as A1.	Same as A1.
A3	Material release (dry vault)	Same as A1.	Same as A1.	Same as A1.	Same as A1.	Same as A1.	Same as A1.	Same as A1.	Same as A1.
A4	Material release (adjacent facility)	Same as A1.	Same as A1.	Same as A1.	Same as A1.	Same as A1.	Same as A1.	Same as A1.	Same as A1.
A5	Criticality in water	Same as A1.	Same as A1.	Same as A1.	Same as A1.	Same as A1.	Same as A1.	Same as A1.	Same as A1.
A6	Criticality	Same as A1.	Same as A1.	Same as A1.	Same as A1.	Same as A1.	Same as A1.	Same as A1.	Same as A1.

	during processing								
A7	External spill/liquid discharge	Same as A1.	Surface-water table contamination expected in area of the release. No adverse effects expected to surface-water or drinking water aquifers.	Same as A1.	Same as A1.	Same as A1.	Same as A1.	Same as A1.	Same as A1.
A8	Internal spill/liquid discharge	Same as A1.	No adverse impact to water resources. The spill is expected to be contained entirely within the building structure.	Same as A1.	Same as A1.	Limited contamination is expected outside the effected building.	Same as A1.	Same as A1.	Same as A1.

water sources would be unlikely. DOE evaluated the effects of a direct discharge of disassembly basin water on water resources (DOE 1990) and believes that impacts on water resources would be minimal.

5.15.4.3 Economic Impacts. DOE expects limited economic impacts as a result of any of the postulated accidents. Any cleanup required would be localized, and the existing workforce and equipment could perform it. Contamination should be contained within a small area inside the SRS boundaries for all eight postulated accident scenarios. The existing workforce could accomplish any required cleanup.

5.15.4.4 National Defense. None of the postulated accidents would affect the DOE national defense mission. Spent nuclear fuel management activities do not involve the production of materials needed for national defense.

5.15.4.5 Environmental Contamination. DOE expects that none of the postulated accident scenarios would result in large areas of contamination. Local contamination is likely around the site of an accident, but in all scenarios should be contained within the SRS boundaries. Minor contamination outside the immediate area of the accident is unlikely to require cleanup of more than a small area inside the Site boundary. Impacts in all cases should be minimal.

5.15.4.6 Endangered Species. There are no Federally listed threatened or endangered species habitats in the immediate vicinity of existing or potential spent nuclear fuel storage or processing facilities (see Section 4.9.4). None of the postulated accident scenarios would likely result in large areas of surface contamination outside the immediate facilities, and DOE does not expect adverse impacts to surface water. Therefore, none of the postulated accident scenarios is likely to impact threatened or endangered species.

5.15.4.7 Land Use. No accident scenario should result in large areas of contamination, nor would the impacts be irreversible. DOE expects no change in land use.

5.15.4.8 Treaty Rights. The environmental impacts of each of the accident scenarios should be contained within the SRS boundaries. Because there are no Native American or public lands within the site boundaries, treaty rights would not be affected.

5.15.5 Adjusted Point Estimate of Risk Summary

The accident scenarios described in Section 5.15.2 differ only slightly between the various alternatives. These scenarios did not account for variations in spent nuclear fuel shipments (including onsite operational transfers) and spent fuel storage inventories across the alternatives. To provide a realistic comparison across alternatives, DOE developed adjustment factors to adjust frequencies or consequences, depending on the specific circumstance of each alternative. Attachment A, Section A.2.9, provides the methodology and justifications used to develop appropriate adjustment factors. This section provides the adjusted point estimates of risk for each accident scenario by receptor group to demonstrate a relative comparison of each alternative on a case-by-case basis. Tables 5-27, 5-28, and 5-29 summarize the adjusted point estimates of risk for each alternative for the maximally exposed individual, the general population to 80 kilometers, and the colocated worker.

5.16 Cumulative Impacts

The Savannah River Site (SRS) contains major U.S. Department of Energy (DOE) and non-DOE facilities, unrelated to spent nuclear fuel, that would continue to operate throughout the life of the spent nuclear fuel management program. The activities associated with these existing facilities produce environmental consequences that this document has included in the baseline environmental conditions (Chapter 4) against which it assesses the consequences of the spent nuclear fuel alternatives. Impacts of both the construction and operation of SRS spent nuclear fuel facilities would be cumulative with the impacts of existing and planned facilities unrelated to spent nuclear fuel.

This cumulative impact assessment considered the incremental and synergistic effects of the operation of the Defense Waste Processing Facility, which is nearing completion, and the Consolidated Incineration Facility, which is under construction, when appropriate and when data existed. For example, the Air Quality analysis factored in emissions from these two facilities when considering potential impacts of operations of spent nuclear fuel facilities. The small volumes of liquid effluent (treated sanitary wastes) currently entering the environment from the Defense Waste Processing Facility, on the other hand, were considered part of the Water Quality baseline. The only major stand alone facilities scheduled to be built in the near future on the SRS are the Savannah River Ecology Laboratory Conference Center and the new Centralized Sanitary Wastewater Treatment Facility. A number of other planned facilities have not been factored into the cumulative impacts analysis because final funding approval has not been received or because decisions on these facilities involve major

Table 5-27. Adjusted point estimates of risk for the maximally exposed offsite individual (radiological accidents).

		No Action	Decentralization			92/93 Planning Basis			Regionalization - A			Centralization			
Accident Description	Attributed	Option 1	Option 2a	Option 2b	Option 2c	Option 3a	Option 3b	Option 3c	Option 4a	Option 4b	Option 4c	Option 5a	Option 5b	Option 5c	Option 5d
A1 - Fuel Assembly Breach	Adjusted Health Effects[a]	1.0x10-6	1.0x10-6	1.0x10-6	1.0x10-6	1.0x10-6	1.0x10-6	1.0x10-6	1.0x10-6	1.0x10-6	1.0x10-6	1.0x10-6	1.0x10-6	1.0x10-6	1.0x10-6
	Adjusted Annual Frequency	1.6x10-1	3.3x10-1	3.5x10-1	1.6x10-1	4.0x10-1	4.0x10-1	2.3x10-1	4.4x10-1	4.4x10-1	2.8x10-1	8.4x10-1	8.4x10-1	6.8x10-1	1.7x10-1
	Adjusted Point	1.6x10-7	3.3x10-7	3.5x10-7	1.6x10-7	4.0x10-7	4.0x10-7	2.3x10-7	4.4x10-7	4.4x10-7	2.8x10-7	8.4x10-7			

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8.4x10-7    6.8x10-7    1.7x10-7
                   Estimate of Riskb
A2 - Processing    Adjusted            (c)          (c)                 (c)          3.4x10-8    (c)
(c)          3.4x10-8    (c)                   (c)          3.4x10-8    (c)               (c)
3.4x10-8    (c)
release            Health Effectsa
                   Adjusted            (c)          (c)                 (c)          2.7x10-1
(c)       (c)          2.7x10-1    (c)                   (c)          2.7x10-1    (c)
(c)          3.5x100     (c)
                   Annual
                   Frequency
                   Adjusted Point      (c)          (c)                 (c)          9.2x10-9
(c)       (c)          9.2x10-9    (c)                   (c)          9.2x10-9    (c)
(c)          1.2x10-7    (c)
                   Estimate of Riskb
A3 - Dry vault     Adjusted            (c)          1.1x10-9            (c)          1.1x10-9
1.2x10-9  (c)          1.2x10-9    1.1x10-9              (c)          1.1x10-9    1.5x10-8
(c)          1.5x10-8    (c)
release            Health Effectsa
                   Adjusted            (c)          1.4x10-3            (c)          1.4x10-3
1.4x10-3  (c)          1.4x10-3    1.4x10-3              (c)          1.4x10-3    1.4x10-3
(c)          1.4x10-3    (c)
                   Annual
                   Frequency
                   Adjusted Point      (c)          1.6x10-12           (c)          1.6x10-12
1.6x10-12 (c)          1.6x10-12   1.5x10-12             (c)          1.5x10-12   2.1x10-11
(c)          2.1x10-11   (c)
                   Estimate of Riskb
A4 - Adjacent      Adjusted            3.0x10-6    3.0x10-6            3.0x10-6    3.0x10-6
3.0x10-6  3.0x10-6    3.0x10-6    3.0x10-6              3.0x10-6    3.0x10-6    3.0x10-6
3.0x10-6    3.0x10-6    3.0x10-6
facility release   Health Effectsa
                   Adjusted            2.4x10-3    5.0x10-3            5.3x10-3    2.5x10-3
5.9x10-3  5.9x10-3    3.4x10-3    6.6x10-3              6.6x10-3    4.2x10-3    1.3x10-2
1.3x10-2    1.0x10-2    2.5x10-3
                   Annual
                   Frequency
                   Adjusted Point      7.2x10-9    1.5x10-8            1.6x10-8    7.4x10-8
1.8x10-8  1.8x10-8    1.0x10-8    2.0x10-8              2.0x10-8    1.3x10-8    3.8x10-8
3.8x10-8    3.0x10-8    7.4x10-9
                   Estimate of Riskb

A5 - Criticality   Adjusted            1.5x10-6    1.5x10-6            1.5x10-6    1.5x10-6
1.5x10-6  1.5x10-6    1.5x10-6    1.5x10-6              1.5x10-6    1.5x10-6    1.5x10-6
1.5x10-6    1.5x10-6    1.5x10-6
in water           Health Effecta
                   Adjusted            3.1x10-3    6.4x10-3            6.8x10-3    3.2x10-3
7.7x10-3  7.7x10-3    4.4x10-3    8.6x10-3              8.6x10-3    5.5x10-3    1.6x10-2
1.6x10-2    1.3x10-2    3.3x10-3
                   Annual
                   Frequency
                   Adjusted Point      4.7x10-9    9.7x10-9            1.0x10-8    4.8x10-9
1.2x10-8  1.2x10-8    6.7x10-9    1.3x10-8              1.3x10-8    8.3x10-9    2.5x10-8
2.5x10-8    2.0x10-8    5.0x10-9
                   Estimate of Riskb
A6 - Criticality   Adjusted            (c)          (c)                 (c)          3.5x10-6    (c)
(c)          3.5x10-6    (c)                   (c)          3.5x10-6    (c)               (c)
3.5x10-6    (c)
during             Health Effectsa
processing
                   Adjusted            (c)          (c)                 (c)          1.5x10-4
(c)       (c)          1.5x10-4    (c)                   (c)          1.4x10-4    (c)
(c)          1.9x10-3    (c)
                   Annual
                   Frequency
                   Adjusted Point      (c)          (c)                 (c)          5.3x10-10
(c)       (c)          5.3x10-10   (c)                   (c)          4.9x10-10   (c)
(c)          6.6x10-9    (c)
                   Estimate of Riskb
A7 - External      Adjusted            2.7x10-6    2.8x10-6            2.8x10-6    2.8x10-6
2.8x10-6  2.8x10-6    2.8x10-6    2.8x10-6              2.8x10-6    2.8x10-6    3.8x10-5
3.8x10-5    3.8x10-5    3.8x10-5
spill/liquid       Health Effectsa
discharge
                   Adjusted            2.0x10-4    2.0x10-4            2.0x10-4    2.0x10-4
2.0x10-4  2.0x10-4    2.0x10-4    2.0x10-4              2.0x10-4    2.0x10-4    2.0x10-4
2.0x10-4    2.0x10-4    2.0x10-4
                   Annual
                   Frequency
                   Adjusted Point      5.4x10-10   5.4x10-10           5.4x10-10   5.4x10-10
5.4x10-10 5.4x10-10   5.4x10-10   5.4x10-10             5.4x10-10   5.4x10-10   7.6x10-9
```

	Estimate of Riskb												7.6x10-9	7.6x10-9	7.6x10-9
A8 - Internal spill/liquid discharge	Adjusted Health Effectsa	1.2x10-13	1.2x10-13	1.2x10-13	1.2x10-13	1.3x10-13	1.3x10-13	1.3x10-13	1.2x10-13	1.2x10-13	1.2x10-13	1.6x10-12	1.6x10-12	1.6x10-12	1.6x10-12
	Adjusted Annual Frequency	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1
	Adjusted Point Estimate of Riskb	1.3x10-14	1.3x10-14	1.3x10-14	1.3x10-14	1.4x10-14	1.4x10-14	1.4x10-14	1.3x10-14	1.3x10-14	1.3x10-14	1.8x10-13	1.8x10-13	1.8x10-13	1.3x10-14

Table 5-27. (continued).

Accident Option Description	Attributea	Regionalization - B Option 4d	Option 4e	Option 4f	4g
A1 - Fuel Assembly Breach	Adjusted Health Effectsa	1.0x10-6	1.0x10-6	1.0x10-6	1.0x10-6
	Adjusted Annual Frequency	4.1x10-1	4.1x10-1	2.5x10-1	1.7x10-1
	Adjusted Point Estimate of Riskb	4.1x10-7	4.1x10-7	2.5x10-7	1.7x10-7
A2 - Processing release	Adjusted Health Effectsa	(c)	(c)	3.4x10-8	(c)
	Adjusted Annual Frequency	(c)	(c)	3.4x10-1	(c)
	Adjusted Point Estimate of Riskb	(c)	(c)	1.2x10-8	(c)
A3 - Dry vault release	Adjusted Health Effectsa	1.4x10-9	(c)	1.4x10-9	(c)
	Adjusted Annual Frequency	1.4x10-3	(c)	1.4x10-3	(c)
	Adjusted Point Estimate of Riskb	2.0x10-12	(c)	2.0x10-12	(c)
A4 - Adjacent facility release	Adjusted Health Effectsa	3.0x10-6	3.0x10-6	3.0x10-6	3.0x10-6
	Adjusted Annual Frequency	6.2x10-3	6.2x10-3	3.7x10-3	2.5x10-3
	Adjusted Point Estimate of Riskb	1.9x10-8	1.9x10-8	1.1x10-8	7.5x10-9
A5 - Criticality in water	Adjusted Health Effecta	1.5x10-6	1.5x10-6	1.5x10-6	1.5x10-6
	Adjusted Annual Frequency	8.0x10-3	8.0x10-3	4.8x10-3	3.3x10-3
	Adjusted Point Estimate of Riskb	1.2x10-8	1.2x10-8	7.2x10-9	4.9x10-9
A6 - Criticality during processing	Adjusted Health Effectsa	(c)	(c)	3.5x10-6	(c)
	Adjusted	(c)	(c)	1.8x10-4	(c)

	Adjusted Annual Frequency Adjusted Point Estimate of Risk[b]	(c)	(c)	6.3x10-10	(c)
A7 - External spill/liquid discharge	Adjusted Health Effects[a]	3.5x10-6	3.5x10-6	3.5x10-6	3.5x10-6
	Adjusted Annual Frequency	2.0x10-4	2.0x10-4	2.0x10-4	2.0x10-4
	Adjusted Point Estimate of Risk[b]	7.0x10-10	7.0x10-10	7.0x10-10	7.0x10-10
A8 - Internal spill/liquid discharge	Adjusted Health Effects[a]	1.6x10-13	1.6x10-13	1.6x10-13	1.6x10-13
	Adjusted Annual Frequency	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1
	Adjusted Point Estimate of Risk[b]	1.7x10-14	1.7x10-14	1.7x10-14	1.7x10-14

a. Units for adjusted health effects are given in terms of potential fatal cancers.

b. Units for adjusted point estimates of risk are given in terms of potential fatal cancers per year.

c. The accident scenario is not included in the spectrum of potential accidents for this case.

d. Adjustment factors were calculated using March 1994 data and information. In-process revisions to these data and information should not result in changes to these factors by more than 10 percent.

Table 5-28. Adjusted point estimates of risk for the colocated worker (radiological accidents).

Accident		No Action	Decentralization			92/93 Planning Basis			Regionalization - A			Centralization			
Description	Attribute	Option 1	Option 2a	Option 2b	Option 2c	Option 3a	Option 3b	Option 3c	Option 4a	Option 4b	Option 4c	Option 5a	Option 5b	Option 5c	Option 5d
A1 - Fuel Assembly Breach	Adjusted Health Effects[a]	4.8x10-6	4.8x10-6	4.8x10-6	4.8x10-6	4.8x10-6	4.8x10-6	4.8x10-6	4.8x10-6	4.8x10-6	4.8x10-6	4.8x10-6	4.8x10-6	4.8x10-6	4.8x10-6
	Adjusted Annual Frequency	1.6x10-1	3.3x10-1	3.5x10-1	1.6x10-1	4.0x10-1	4.0x10-1	2.3x10-1	4.4x10-1	4.4x10-1	2.8x10-1	8.4x10-1	8.4x10-1	6.8x10-1	1.7x10-1
	Adjusted Point Estimate of Risk[b]	7.7x10-7	1.6x10-6	1.7x10-6	7.7x10-7	1.9x10-6	1.9x10-6	1.1x10-6	2.1x10-6	2.1x10-6	1.3x10-6	4.0x10-6	4.0x10-6	3.3x10-6	8.2x10-7
A2 - Processing release	Adjusted Health Effects[a]	(c)	(c)	(c)	3.6x10-8	(c)	(c)	3.6x10-8	(c)	(c)	3.6x10-8	(c)	(c)	3.6x10-8	(c)
	Adjusted Annual Frequency	(c)	(c)	(c)	2.7x10-1	(c)	(c)	2.7x10-1	(c)	(c)	2.7x10-1	(c)	(c)	3.5x100	(c)
	Adjusted Point Estimate of Risk[b]	(c)	(c)	(c)	9.7x10-9	(c)	(c)	9.7x10-9	(c)	(c)	9.7x10-9	(c)	(c)	1.3x10-7	(c)
A3 - Dry vault release	Adjusted Health Effects[a]	(c)	(d)	(c)	(d)	(d)	(c)	(d)	(d)	(c)	(d)	(d)	(c)	(d)	(c)
	Adjusted Annual Frequency	(c)	(d)	(c)	(d)	(d)	(c)	(d)	(d)	(c)	(d)	(d)	(c)	(d)	(c)

	Adjusted Point	(c)	(d)	(c)	(d)	(d)	(c)	(d)	(d)	(c)	(d)	(d)	(c)	(d)	(c)
A4 - Adjacent facility release	Estimate of Riskb Adjusted	2.0x10-5	2.0x10-5	2.0x10-5	2.0x10-5	2.0x10-5	2.0x10-5	2.0x10-5	2.0x10-5	2.0x10-5	2.0x10-5	2.0x10-5	2.0x10-5	2.0x10-5	2.0x10-5
	Health Effectsa Adjusted	2.4x10-3	5.0x10-3	5.3x10-3	2.5x10-3	5.9x10-3	5.9x10-3	3.4x10-3	6.6x10-3	6.6x10-3	4.2x10-3	1.3x10-2	1.3x10-2	1.0x10-2	2.5x10-3
	Annual Frequency Adjusted Point	4.8x10-8	1.0x10-7	1.1x10-7	4.9x10-8	1.2x10-7	1.2x10-7	6.8x10-8	1.3x10-7	1.3x10-7	8.5x10-8	2.5x10-7	2.5x10-7	2.0x10-7	5.0x10-8
A5 - Criticality in water	Estimate of Riskb Adjusted	5.6x10-5	5.6x10-5	5.6x10-5	5.6x10-5	5.6x10-5	5.6x10-5	5.6x10-5	5.6x10-5	5.6x10-5	5.6x10-5	5.6x10-5	5.6x10-5	5.6x10-5	5.6x10-5
	Health Effectsa Adjusted	3.1x10-3	6.4x10-3	6.8x10-3	3.2x10-3	7.7x10-3	7.7x10-3	4.4x10-3	8.6x10-3	8.6x10-3	5.5x10-3	1.6x10-2	1.6x10-2	1.3x10-2	3.3x10-3
	Annual Frequency Adjusted Point	1.7x10-7	3.6x10-7	3.8x10-7	1.8x10-7	4.3x10-7	4.3x10-7	2.5x10-7	4.8x10-7	4.8x10-7	3.1x10-7	9.0x10-7	9.0x10-7	7.3x10-7	1.8x10-7
A6 - Criticality during processing	Estimate of Riskb Adjusted	(c)	(c)	(c)	1.0x10-4	(c)	(c)	1.0x10-4	(c)	(c)	1.0x10-4	(c)	(c)	1.0x10-4	(c)
	Health Effectsa Adjusted	(c)	(c)	(c)	1.5x10-4	(c)	(c)	1.5x10-4	(c)	(c)	1.4x10-4	(c)	(c)	1.9x10-3	(c)
	Annual Frequency Adjusted Point	(c)	(c)	(c)	1.5x10-8	(c)	(c)	1.5x10-8	(c)	(c)	1.4x10-8	(c)	(c)	1.9x10-7	(c)
A7 - External spill/liquid discharge	Estimate of Riskb Adjusted	3.0x10-5	3.1x10-5	3.1x10-5	3.1x10-5	3.2x10-5	3.2x10-5	3.2x10-5	3.1x10-5	3.1x10-5	3.1x10-5	4.1x10-4	4.1x10-4	4.1x10-4	4.1x10-4
	Health Effectsa Adjusted	2.0x10-4	2.0x10-4	2.0x10-4	2.0x10-4	2.0x10-4	2.0x10-4	2.0x10-4	2.0x10-4	2.0x10-4	2.0x10-4	2.0x10-4	2.0x10-4	2.0x10-4	2.0x10-4
	Annual Frequency Adjusted Point	6.0x10-9	6.2x10-9	6.2x10-9	6.2x10-9	6.4x10-9	6.4x10-9	6.4x10-9	6.2x10-9	6.2x10-9	6.2x10-9	8.2x10-8	8.2x10-8	8.2x10-8	8.2x10-8
A8 - Internal spill/liquid discharge	Estimate of Riskb Adjusted	8.0x10-15	8.3x10-15	8.3x10-15	8.3x10-15	8.4x10-15	8.4x10-15	8.4x10-15	8.2x10-15	8.2x10-15	8.2x10-15	1.1x10-13	1.1x10-13	1.1x10-13	1.1x10-13
	Health Effectsa Adjusted	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1
	Annual Frequency Adjusted Point	8.8x10-16	9.2x10-16	9.2x10-16	9.2x10-16	9.2x10-16	9.2x10-16	9.2x10-16	9.1x10-16	9.1x10-16	9.1x10-16	1.2x10-14	1.2x10-14	1.2x10-14	1.2x10-14
	Estimate of Riskb														

Table 5-28. (continued).

Accident Description	Attribute	Regionalization - B Option 4d	Option 4e	Option 4f	Option 4g
A1 - Fuel Assembly Breach	Adjusted	4.8x10-6	4.8x10-6	4.8x10-6	4.8x10-6
	Health Effectsa Adjusted	4.1x10-1	4.1x10-1	2.5x10-1	1.7x10-1
	Annual Frequency Adjusted Point	2.0x10-6	2.0x10-6	1.2x10-6	8.1x10-7

	Estimate of Riskb				
A2 - Processing release	Adjusted	(c)	(c)	3.6x10-8	(c)
	Health Effectsa Adjusted	(c)	(c)	3.4x10-1	(c)
	Annual Frequency Adjusted Point	(c)	(c)	1.2x10-8	(c)
	Estimate of Riskb				
A3 - Dry vault release	Adjusted	(c)	(c)	(d)	(c)
	Health Effectsa Adjusted	(c)	(c)	(d)	(c)
	Annual Frequency Adjusted Point	(c)	(c)	(d)	(c)
	Estimate of Riskb				
A4 - Adjacent facility release	Adjusted	2.0x10-5	2.0x10-5	2.0x10-5	2.0x10-5
	Health Effectsa Adjusted	6.2x10-3	6.2x10-3	3.7x10-3	2.5x10-3
	Annual Frequency Adjusted Point	1.2x10-7	1.2x10-7	7.4x10-7	5.0x10-8
	Estimate of Riskb				
A5 - Criticality in water	Adjusted	5.6x10-5	5.6x10-5	5.6x10-5	5.6x10-5
	Health Effectsa Adjusted	8.0x10-3	8.0x10-3	4.8x10-3	3.3x10-3
	Annual Frequency Adjusted Point	4.5x10-7	4.5x10-7	2.7x10-7	1.8x10-7
	Estimate of Riskb				
A6 - Criticality during processing	Adjusted	(c)	(c)	1.0x10-4	(c)
	Health Effectsa Adjusted	(c)	(c)	1.8x10-4	(c)
	Annual Frequency Adjusted Point	(c)	(c)	1.8x10-8	(c)
	Estimate of Riskb				
A7 - External spill/liquid discharge	Adjusted	3.9x10-3	3.9x10-3	3.9x10-3	3.9x10-3
	Health Effectsa Adjusted	2.0x10-4	2.0x10-4	2.0x10-4	2.0x10-4
	Annual Frequency Adjusted Point	7.8x10-7	7.8x10-7	7.8x10-7	7.8x10-7
	Estimate of Riskb				
A8 - Internal spill/liquid discharge	Adjusted	1.0x10-14	1.0x10-14	1.0x10-14	1.0x10-14
	Health Effectsa Adjusted	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1
	Annual Frequency Adjusted Point	1.2x10-15	1.2x10-15	1.2x10-15	1.2x10-15
	Estimate of Riskb				

a. Units for adjusted health effects are given in terms of potential fatal cancers.
b. Units for adjusted point estimates of risk are given in terms of potential fatal cancers per year.
c. The accident scenario is not included in the spectrum of potential accidents for this case.
d. The safety analyses from which information was extracted for these accidents were written before issuance of DOE Order 5480.23; previous Orders did not require the inclusion of colocated workers.

Table 5-29. Adjusted point estimates of risk for the general population - 80 kilometers (radiological accidents).

		No Action	Decentralization			92/93 Planning Basis			Regionalization - A			Centralization			
Accident Description	Attribute	Option 1	Option 2a	Option 2b	Option 2c	Option 3a	Option 3b	Option 3c	Option 4a	Option 4b	Option 4c	Option 5a	Option 5b	Option 5c	Option 5d
A1 - Fuel Assembly Breach	Adjusted Health Effects[a]	8.5x10-3	8.5x10-3	8.5x10-3	8.5x10-3	8.5x10-3	8.5x10-3	8.5x10-3	8.5x10-3	8.5x10-3	8.5x10-3	8.5x10-3	8.5x10-3	8.5x10-3	8.5x10-3
	Adjusted Annual Frequency	1.6x10-1	3.3x10-1	3.5x10-1	1.6x10-1	4.0x10-1	4.0x10-1	2.3x10-1	4.4x10-1	4.4x10-1	2.8x10-1	8.4x10-1	8.4x10-1	6.8x10-1	1.7x10-1
	Adjusted Point Estimate of Risk[b]	1.4x10-3	2.8x10-3	3.0x10-3	1.4x10-3	3.4x10-3	3.4x10-3	2.0x10-3	3.7x10-3	3.7x10-3	2.4x10-3	7.2x10-3	7.2x10-3	5.8x10-3	1.4x10-3
A2 - Processing release	Adjusted Health Effects[a]	(c)	(c)	(c)	2.6x10-4	(c)	(c)	2.6x10-4	(c)	(c)	2.6x10-4	(c)	(c)	2.6x10-4	(c)
	Adjusted Annual Frequency	(c)	(c)	(c)	2.7x10-1	(c)	(c)	2.7x10-1	(c)	(c)	2.7x10-1	(c)	(c)	3.5x100	(c)
	Adjusted Point Estimate of Risk[b]	(c)	(c)	(c)	7.0x10-5	(c)	(c)	7.0x10-5	(c)	(c)	7.0x10-5	(c)	(c)	9.1x10-4	(c)
A3 - Dry vault release	Adjusted Health Effects[a]	(c)	3.6x10-6	(c)	3.6x10-6	3.7x10-6	(c)	3.7x10-6	3.6x10-6	(c)	3.6x10-6	4.8x10-5	(c)	4.8x10-5	(c)
	Adjusted Annual Frequency	(c)	1.4x10-3	(c)	1.4x10-3	1.4x10-3	(c)	1.4x10-3	1.4x10-3	(c)	1.4x10-3	1.4x10-3	(c)	1.4x10-3	(c)
	Adjusted Point Estimate of Risk[b]	(c)	5.0x10-9	(c)	5.0x10-9	5.0x10-9	(c)	5.1x10-9	5.0x10-9	(c)	5.0x10-9	6.7x10-8	(c)	6.7x10-8	(c)
A4 - Adjacent facility release	Adjusted Health Effects[a]	2.5x10-2	2.5x10-2	2.5x10-2	2.5x10-2	2.5x10-2	2.5x10-2	2.5x10-2	2.5x10-2	2.5x10-2	2.5x10-2	2.5x10-2	2.5x10-2	2.5x10-2	2.5x10-2
	Adjusted Annual Frequency	2.4x10-3	5.0x10-3	5.3x10-3	2.5x10-3	5.9x10-3	5.9x10-3	3.4x10-3	6.6x10-3	6.6x10-3	4.2x10-3	1.3x10-2	1.3x10-2	1.0x10-2	2.5x10-3
	Adjusted Point Estimate of Risk[b]	6.0x10-5	1.2x10-4	1.3x10-4	6.2x10-5	1.5x10-4	1.5x10-4	8.5x10-5	1.7x10-4	1.7x10-4	1.1x10-4	3.2x10-4	3.2x10-4	2.5x10-4	6.2x10-5
A5 - Criticality in water	Adjusted Health Effects[a]	4.4x10-3	4.4x10-3	4.4x10-3	4.4x10-3	4.4x10-3	4.4x10-3	4.4x10-3	4.4x10-3	4.4x10-3	4.4x10-3	4.4x10-3	4.4x10-3	4.4x10-3	4.4x10-3
	Adjusted	3.1x10-3	6.4x10-3	6.8x10-3	3.2x10-3	7.7x10-3	7.7x10-3	4.4x10-3	8.6x10-3	8.6x10-3	5.5x10-3	1.6x10-2			

	Annual Frequency												1.6x10-2	1.3x10-2	3.3x10-3
	Adjusted Point Estimate of Riskb	1.4x10-5	2.8x10-4	3.0x10-4	1.4x10-4	3.4x10-4	3.4x10-4	1.9x10-4	3.8x10-4	3.8x10-4	2.4x10-5	7.0x10-4	7.0x10-5	5.7x10-4	1.5x10-5
A6 - Criticality during processing	Adjusted Health Effectsa	(c)	(c)	(c)	4.3x10-3	(c)	(c)	4.3x10-3	(c)	(c)	4.3x10-3	(c)	(c)	4.3x10-3	(c)
	Adjusted Annual Frequency	(c)	(c)	(c)	1.5x10-4	(c)	(c)	1.5x10-4	(c)	(c)	1.4x10-4	(c)	(c)	1.9x10-3	(c)
	Adjusted Point Estimate of Riskb	(c)	(c)	(c)	6.5x10-7	(c)	(c)	6.5x10-7	(c)	(c)	6.0x10-7	(c)	(c)	8.2x10-6	(c)
A7 - External spill/liquid discharge	Adjusted Health Effectsa	9.0x10-3	9.4x10-3	9.4x10-3	9.4x10-3	9.5x10-3	9.5x10-3	9.5x10-3	9.3x10-3	9.3x10-3	9.3x10-3	1.2x10-1	1.2x10-1	1.2x10-1	1.2x10-1
	Adjusted Annual Frequency	2.0x10-4	2.0x10-4	2.0x10-4	2.0x10-4	2.0x10-4	2.0x10-4	2.0x10-4	2.0x10-4	2.0x10-4	2.0x10-4	2.0x10-4	2.0x10-4	2.0x10-4	2.0x10-4
	Adjusted Point Estimate of Riskb	1.8x10-6	1.9x10-6	1.9x10-6	1.9x10-6	1.9x10-6	1.9x10-6	1.9x10-6	1.9x10-6	1.9x10-6	1.9x10-6	2.4x10-5	2.4x10-5	2.4x10-5	2.4x10-5
A8 - Internal spill/liquid discharge	Adjusted Health Effectsa	1.0x10-9	1.0x10-9	1.0x10-9	1.0x10-9	1.1x10-9	1.1x10-9	1.1x10-9	1.0x10-9	1.0x10-9	1.0x10-9	1.4x10-8	1.4x10-8	1.4x10-8	1.4x10-8
	Adjusted Annual Frequency	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1
	Adjusted Point Estimate of Riskb	1.1x10-10	1.1x10-10	1.1x10-10	1.1x10-10	1.2x10-10	1.2x10-10	1.2x10-10	1.1x10-10	1.1x10-10	1.1x10-10	1.5x10-9	1.5x10-9	1.5x10-9	1.5x10-9

Table 5-29. (continued).

		Regionalization - B			
Accident Option Description	Attribute	Option 4d	Option 4e	Option 4f	4g
A1 - Fuel Assembly Breach	Adjusted Health Effectsa	8.5x10-3	8.5x10-3	8.5x10-3	8.5x10-3
	Adjusted Annual Frequency	4.1x10-1	4.1x10-1	2.5x10-1	1.7x10-1
	Adjusted Point Estimate of Riskb	3.5x10-3	3.5x10-3	2.1x10-3	1.4x10-3
A2 - Processing Release	Adjusted Health Effectsa	(c)	(c)	2.6x10-4	(c)
	Adjusted Annual Frequency	(c)	(c)	3.4x10-1	(c)
	Adjusted Point Estimate of Riskb	(c)	(c)	8.8x10-5	(c)
A3 - Dry vault Release	Adjusted Health Effectsa	4.6x10-6	(c)	4.6x10-6	(c)
	Adjusted Annual	1.4x10-3	(c)	1.4x10-3	(c)

	Adjusted Point Estimate of Risk[b]	6.4x10-4	(c)	6.4x10-4	(c)
A4 - Adjacent Facility Release	Adjusted Health Effects[a]	2.5x10-2	2.5x10-2	2.5x10-2	2.5x10-2
	Adjusted Annual Frequency	6.2x10-3	6.2x10-3	3.7x10-3	2.5x10-3
	Adjusted Point Estimate of Risk[b]	1.6x10-4	1.6x10-4	9.2x10-5	6.3x10-5
A5 - Criticality in water	Adjusted Health Effects[a]	4.4x10-3	4.4x10-3	4.4x10-3	4.4x10-3
	Adjusted Annual Frequency	8.0x10-3	8.0x10-3	4.8x10-3	3.3x10-3
	Adjusted Point Estimate of Risk[b]	3.5x10-5	3.5x10-5	2.1x10-5	1.4x10-5
A6 - Criticality during processing	Adjusted Health Effects[a]	(c)	(c)	4.3x10-3	(c)
	Adjusted Annual Frequency	(c)	(c)	1.8x10-4	(c)
	Adjusted Point Estimate of Risk[b]	(c)	(c)	7.7x10-7	(c)
A7 - External spill/liquid discharge	Adjusted Health Effects[a]	1.2x10-2	1.2x10-2	1.2x10-2	1.2x10-2
	Adjusted Annual Frequency	2.0x10-4	2.0x10-4	2.0x10-4	2.0x10-4
	Adjusted Point Estimate of Risk[b]	2.4x10-6	2.4x10-6	2.4x10-6	2.4x10-6
A8 - Internal spill/liquid discharge	Adjusted Health Effects[a]	1.3x10-9	1.3x10-9	1.3x10-9	1.3x10-9
	Adjusted Annual Frequency	1.1x10-1	1.1x10-1	1.1x10-1	1.1x10-1
	Adjusted Point Estimate of Risk[b]	1.4x10-10	1.4x10-10	1.4x10-10	1.4x10-10

a. Units for adjusted health effects are given in terms of potential fatal cancers.
b. Units for adjusted point estimates of risk are given in terms of potential fatal cancers per year.
c. The accident scenario is not included in the spectrum of potential accidents for this case.

unresolved DOE policy issues. For example, this cumulative impact assessment does not consider long-term reconfiguration issues. Table 5-30 presents a summary of cumulative impacts associated with the various spent fuel management alternatives.

5.16.1 Land Use

The land committed to spent nuclear fuel management activities at the SRS would lie, for the most part, within existing onsite industrial compounds or undeveloped onsite areas devoted to the continued mission of the Site. Under two of the alternatives - Regionalization by Location (at SRS) and Centralization (at SRS) - a new Expended Core Facility could be required to examine and characterize spent nuclear fuels from naval installations east of the Mississippi. Two locations have been proposed for the Expended Core Facility, one in the approximate center of the SRS and the other at the old Allied General Nuclear Services facility (or "Barnwell Nuclear Fuel Plant") that is located off Road G (and near SRS Barricade 4) just east of and adjacent to the Site.

Previously-undeveloped land committed to new spent nuclear fuel facilities (excluding the Expended Core Facility) would be limited to a maximum of approximately 100 acres (0.4 square kilometer). Depending on the location chosen, an additional 30 acres (0.1 square kilometer) could be required for a new Expended Core Facility. Thus, a maximum of 130 acres (0.5 square kilometer) could be converted from woodlands or old fields to industrial facilities and supporting infrastructure under the bounding options, Option 5a (Centralization - Dry Storage) and Option 5c (Centralization - Processing). Any site used for the support of spent nuclear fuel activities would be under government control. With the exception of the Barnwell Nuclear Fuel facility, which the Navy would purchase from Allied General Nuclear Services for an offsite Expended Core Facility, DOE would not require any additional land from the public domain for SRS spent nuclear fuel management facilities.

Ground was broken for the new Savannah River Ecology Laboratory Conference Center in May 1994. The new facility will occupy a 70-acre area, but only 5 to 10 acres will be cleared and graded for the new conference center, parking areas, and an access road. The remaining 60-65 acres will be managed as a nature study area and preserve. Thus, the Savannah River Ecology Laboratory Conference Center will require conversion of 5 to 10 acres of planted pines or pine/mixed hardwood (depending on the exact location of the building) to light-industrial/public use.

Table 5-30. Cumulative impacts associated with construction and operation of spent fuel alternatives at Savannah River Site.

ALTERNATIVE 1 - NO ACTION

	Option 1 Wet Storage
Land Use	No new land committed to new use.
Socioeconomics	A maximum of 50 new jobs created annually during construction; no new jobs created during operation.
Air Resources	Site emissions would not exceed any air quality standard. Table 5-31 lists cumulative Site nonradioactive releases at the SRS boundary.
Occupational and Public Health and Safety	Radioactive airborne releases, expressed as cumulative dose to a maximally exposed individual at the Site boundary, would be 9.0x10-5 rem.
Materials and Waste Management	High-Level: Current generation levels Transuranic: Current generation levels Low-Level: Current generation levels Mixed: Current generation levels Hazardous: Current generation levels Sanitary: Current generation levels

ALTERNATIVE 2 - DECENTRALIZATION

	Option 2a Dry Storage	Option 2b Wet Storage	Option 2c Processing
Land Use	Small amount of land (<10 acres) committed to new use.	Small amount of land (<10 acres) committed to new use.	Small amount of land (<10 acres) committed to new use.
Socioeconomics	Construction jobs: 600 peak Operation: No new jobs	Construction jobs: 600 peak Operation: No new jobs	Construction jobs: 550 peak Operation: No new jobs
Air Resources	Site emissions would not exceed any air quality standard. Table 5-31 lists cumulative Site nonradioactive releases at the SRS boundary.	Site emissions would not exceed any air quality standard. Table 5-31 lists cumulative Site nonradioactive releases at the SRS boundary.	Site emissions would not exceed any air quality standard. Table 5-31 lists cumulative Site nonradioactive releases at the SRS boundary.
Occupational and Public Health and Safety	Radioactive airborne releases, expressed as cumulative dose to a maximally exposed individual at the Site boundary, would be 9.0x10-5 rem.	Radioactive airborne releases, expressed as cumulative dose to a maximally exposed individual at the Site boundary, would be 9.0x10-5 rem.	Radioactive airborne releases, expressed as cumulative dose to a maximally exposed individual at the Site boundary, would be 4.4x10-4 rem.
Materials and Waste Management	High-Level: No change Transuranic: 6% increase Low-Level: No change Mixed: No changea	High-Level: No change Transuranic: 6% increase Low-Level: No change Mixed: No changea	High-Level: 475% increase Transuranic: 12% increase Low-Level: 100% increase Mixed: No changea

	Hazardous: No changea Sanitary: No changeb	Hazardous: No changea Sanitary: No changeb	Hazardous: No changea Sanitary: No changeb
ALTERNATIVE 3 - 1992/1993 PLANNING BASIS			
	Option 3a Dry Storage	Option 3b Wet Storage	Option 3c Processing
Land Use	Small amount of land (<10 acres) committed to new use.	Small amount of land (<10 acres) committed to new use.	Small amount of land (<10 acres) committed to new use.
Socioeconomics	Construction jobs: 600 peak Operation: No new jobs	Construction jobs: 650 peak Operation: No new jobs	Construction jobs: 550 peak Operation: No new jobs
Air Resources	Site emissions would not exceed any air quality standard. Table 5-31 lists cumulative Site nonradioactive releases at the SRS boundary.	Site emissions would not exceed any air quality standard. Table 5-31 lists cumulative Site nonradioactive releases at the SRS boundary.	Site emissions would not exceed any air quality standard. Table 5-31 lists cumulative Site nonradioactive releases at the SRS boundary.
Occupational and Public Health and Safety	Radioactive airborne releases, expressed as cumulative dose to a maximally exposed individual at the Site boundary, would be 9.0x10-5 rem.	Radioactive airborne releases, expressed as cumulative dose to a maximally exposed individual at the Site boundary, would be 9.0x10-5 rem.	Radioactive airborne releases, expressed as cumulative dose to a maximally exposed individual at the Site boundary, would be 4.5x10-4 rem.
Materials and Waste Management	High-Level: No change Transuranic: 6% increase Low-Level: No change Mixed: No changea Hazardous: No changea Sanitary: No changeb	High-Level: No change Transuranic: 6% increase Low-Level: No change Mixed: No changea Hazardous: No changea Sanitary: No changeb	High-Level: 325% increase Transuranic: 12% increase Low-Level: 87.5% increase Mixed: No changea Hazardous: No changea Sanitary: No changeb
ALTERNATIVE 4 - REGIONALIZATION			
	Option 4a Dry Storage	Option 4b Wet Storage	Option 4c Processing
Land Use	Small amount of land (<10 acres) committed to new use.	Small amount of land (<10 acres) committed to new use.	Small amount of land (<10 acres) committed to new use.
Socioeconomics	Construction jobs: 650 peak Operation: No new jobs	Construction jobs: 650 peak Operation: No new jobs	Construction jobs: 550 peak Operation: No new jobs
Air Resources	Site emissions would not exceed any air quality standard. Table 5-31 lists cumulative Site nonradioactive releases at the SRS boundary.	Site emissions would not exceed any air quality standard. Table 5-31 lists cumulative Site nonradioactive releases at the SRS boundary.	Site emissions would not exceed any air quality standard. Table 5-31 lists cumulative Site nonradioactive releases at the SRS boundary.
Occupational and Public Health and Safety	Radioactive airborne releases, expressed as cumulative dose to a maximally exposed individual at the Site boundary, would be 9.0x10-5 rem.	Radioactive airborne releases, expressed as cumulative dose to a maximally exposed individual at the Site boundary, would be 9.0x10-5 rem.	Radioactive airborne releases, expressed as cumulative dose to a maximally exposed individual at the Site boundary, would be 4.7x10-4 rem.
	Option 4a Dry Storage	Option 4b Wet Storage	Option 4c Processing
Materials and Waste Management	High-Level: No change Transuranic: No change Low-Level: No change Mixed: No changea Hazardous: No changea Sanitary: No changeb	High-Level: No change Transuranic: No change Low-Level: No change Mixed: No changea Hazardous: No changea Sanitary: No changeb	High-Level: 475% increase Transuranic: 6% increase Low-Level: 97.5% increase Mixed: No changea Hazardous: No changea Sanitary: No changeb
	Option 4d Dry Storage	Option 4e Wet Storage	Option 4f Processing
Land Use	Approximately 40 acres committed to new use.	Approximately 35 acres committed to new use.	Approximately 35 acres committed to new use.
Socioeconomics	Construction jobs: 910 peak Operation: No new jobs	Construction jobs: 910 peak Operation: No new jobs	Construction jobs: 860 peak Operation: No new jobs
Air Resources	Site emissions would not exceed any air quality standard. Table 5-31 lists cumulative Site nonradioactive releases	Site emissions would not exceed any air quality standard. Table 5-31 lists cumulative Site nonradioactive releases	Site emissions would not exceed any air quality standard. Table 5-31 lists cumulative Site nonradioactive releases at the SRS boundary.

	at the SRS boundary.	at the SRS boundary.	
Occupational and Public Health and Safety	Radioactive airborne releases, expressed as cumulative dose to a maximally exposed individual at the Site boundary, would be 9.0x10-5 rem.	Radioactive airborne releases, expressed as cumulative dose to a maximally exposed individual at the Site boundary, would be 9.0x10-5 rem.	Radioactive airborne releases, expressed as cumulative dose to a maximally exposed individual at the Site boundary, would be 4.7x10-4 rem.
Materials and Waste Management	High-Level: No change Transuranic: No change Low-Level: No change Mixed: No changea Hazardous: No changea Sanitary: No changeb	High-Level: No change Transuranic: No change Low-Level: No change Mixed: No changea Hazardous: No changea Sanitary: No changeb	High-Level: 475% increase Transuranic: 6% increase Low-Level: 97.5% increase Mixed: No changea Hazardous: No changea Sanitary: No changeb
	Option 4g Ship Out		
Land Use	Less than one acre of land committed to new use.		
Socioeconomics	Construction jobs: 200 peak Operation: No new jobs		
Air Resources	Site emissions would not exceed any air quality standard. Table 5-31 lists cumulative site nonradioactive releases at the SRS boundary.		
Occupational and Public Health and Safety	Radioactive airborne releases, expressed as cumulative dose to a maximally exposed individual at the Site boundary, would be (less than) <9.0x10-5 rem.		
Materials and Waste Management	High-Level: Reduced volume of waste produced Transuranic: 6% increase Low-Level: No change Mixed: No changea Hazardous: No changea Sanitary: No changeb		
	ALTERNATIVE 5 - CENTRALIZATION		
	Option 5a Dry Storage	Option 5b Wet Storage	Option 5c Processing
Land Use	100-130 acres of land committed to new use.	70-80 acres of land committed to new use.	100-130 acres of land committed to new use.
Socioeconomics	Construction: 2,550 peak Operation: No new jobs	Construction: 2,700 peak Operation: No new jobs	Construction: 2,550 peak Operation: No new jobs
Air Resources	Site emissions would not exceed any air quality standard. Table 5-31 lists cumulative Site nonradioactive releases at the SRS boundary.	Site emissions would not exceed any air quality standard. Table 5-31 lists cumulative Site nonradioactive releases at the SRS boundary.	Site emissions would not exceed any air quality standard. Table 5-31 lists cumulative Site nonradioactive releases at the SRS boundary.
Occupational and Public Health and Safety	Radioactive airborne releases, expressed as cumulative dose to a maximally exposed individual at the Site boundary, would be 9.0x10-5 rem.	Radioactive airborne releases, expressed as cumulative dose to a maximally exposed individual at the Site boundary, would be 9.0x10-5 rem.	Radioactive airborne releases, expressed as cumulative dose to a maximally exposed individual at the Site boundary, would be 4.7x10-4 rem.
Materials and Waste Management	High-Level: Reduced volume of waste produced Transuranic: Reduced volume of waste produced Low-Level: No change Mixed: No changea Hazardous: No changea Sanitary: No changeb	High-Level: 475% increase Transuranic: 18% increase Low-Level: No change Mixed: No changea Hazardous: No changea Sanitary: No changeb	High-Level: 475% increase Transuranic: 18% increase Low-Level: 100% increase Mixed: No changea Hazardous: No changea Sanitary: No changeb
	Option 5d Ship Out		
Land Use	Less than one acre of land committed to new use.		
Socioeconomics	Construction: 200 peak Operation: No new jobs		
Air Resources	Site emissions would not exceed any air quality standard. Table 5-31 lists cumulative Site nonradioactive releases at the SRS boundary.		
Occupational and Public Health and	Radioactive airborne releases, expressed as cumulative dose to a maximally exposed individual at the Site boundary, would be 9.0x10-5 rem.		

Safety	
Materials and Waste Management	High-Level: Reduced volume of waste produced
	Transuranic: 6% increase
	Low-Level: No change
	Mixed: No changea
	Hazardous: No changea
	Sanitary: No changeb

a. Not expected to change; no analysis conducted.
b. Not expected to change; based on projected employment levels at SRS.

Construction on the new Centralized Sanitary Wastewater Treatment Facility is scheduled to begin in 1994 and should be completed in 1995. This new facility will be built approximately 1 mile south of F-Area on Burma Road. Building the central facility will require clearing approximately 6 acres of planted pines. An 18 mile trunkline/collection system will also be required, using existing transmission line and steam line rights-of-way to the extent possible. This trunkline will be located in the northwest quadrant of the SRS, and will connect the new Centralized Sanitary Wastewater Treatment Facility to A-Area, F-/H-Areas, and C-Area.

Depending on the spent nuclear fuel management alternative chosen, a total of 150 acres of SRS land could be cleared and converted to facilities and infrastructure as a result of spent nuclear fuel management (including an Expended Core Facility), construction of the Savannah River Ecology Laboratory Conference Center, and completion of the Centralized Sanitary Wastewater Treatment Facility. This represents less than 0.1 percent of the undeveloped land on the SRS, and will have minimal cumulative impact on long-term land use locally and regionally.

5.16.2 Socioeconomics

There would be minimal cumulative impacts on the socioeconomic resources of the SRS region from any spent fuel management alternative. The greatest change in employment would occur under the Centralization Alternative, which would include construction and operation of an Expended Core Facility at SRS. Construction of an Expended Core Facility would require an estimated 850 additional employees in the peak year (1999), while operation of the facility would add a maximum of approximately 500 full-time jobs. DOE anticipates that overall employment on the Site will decline during the first 5 years of the spent fuel management period and will stabilize thereafter as the SRS mission changes. Workers who might otherwise lose their jobs could be employed by SRS in spent fuel program activities. Therefore, DOE expects little or no direct increase in employment due to the program. The Site would fill any new jobs from the existing regional labor force.

5.16.3 Air Quality

Table 5-31 compares the cumulative emissions of nonradioactive pollutants from the SRS, including those from the proposed spent nuclear fuel alternatives, to the pertinent regulatory standards. The values provided are the maximum concentrations that would occur at ground level at the Site boundary. Not all maximum concentrations would occur at the same location.

Table 5-31. Total maximum ground-level concentrations (yg/cubic meter) of criteria and toxic air pollutants at SRS boundary resulting from normal operations and spent nuclear fuel management alternatives. ,b

Emissions	Averaging Time	Alternatives 1 through 4		
		Option a Dry Storage	Option b Wet Storage	Option c Processing
Criteria Pollutants				
NOx		An4 (4%)	4 (4%)	15 (15%)
SOx		An10 (12%)	10 (12%)	10 (12%)
		24185.0 (50%)	185.0 (50%)	185.4 (50%)
		3-634 (49%)	634 (49%)	637 (49%)
PM10		An3 (6%)	3 (6%)	3 (6%)
		2456.0 (37%)	56.0 (37%)	56.4 (37%)
TSP		An11 (17%)	11 (17%)	11 (17%)
Ozone (as VOC)		1-N/Ad	N/Ad	N/Ad
Gaseous fluoride (as HF)		1-0.03 (4%)	0.03 (4%)	0.05 (6%)
		1-0.15 (9%)	0.15 (9%)	0.25 (16%)
		240.31 (11%)	0.31 (11%)	0.51 (18%)
		120.62 (17%)	0.62 (17%)	1.02 (28%)
Lead		An<0.01 (<1%)	<0.01 (<1%)	<0.01 (<1%)

CO	8-23.1 (0.2%) 1-181 (0.4%)	23.1 (0.2%) 181 (0.4%)	27.3 (0.3%) 212 (0.5%)
Toxic Pollutants			
Nitric acid	246.7 (5%)	6.7 (5%)	7.7 (6%)
1,1,1-Trichloroethane	2422 (0.2%)	22 (0.02%)	22 (0.2%)
Benzene	2431 (21%)	31 (21%)	31 (21%)
Ethanolamine	24<0.01 (<0.1%)	<0.01 (<0.1%)	<0.01 (<0.1%)
Ethylbenzene	240.12 (<0.1%)	0.12 (<0.1%)	0.12 (<0.1%)
Ethylene glycol	240.08 (<0.1%)	0.08 (<0.1%)	0.08 (<0.1%)
Formaldehyde	24<0.01 (<0.1%)	<0.01 (<0.1%)	<0.01 (<0.1%)
Glycol ethers	24<0.01 N/A	<0.01 N/A	<0.01 N/A
Hexachloronaphthalene	24<0.01 (<1%)	<0.01 (<1%)	<0.01 (<1%)
Hexane	240.07 (<0.1%)	0.07 (<0.1%)	0.11 (<0.1%)
Manganese	240.10 (0.4%)	0.10 (0.4%)	0.10 (0.4%)
Methanol	240.51 (<0.1%)	0.51 (<0.1%)	0.51 (<0.1%)
Methyl ethyl ketone	240.99 (<0.1%)	0.99 (<0.1%)	0.99 (<0.1%)
Methyl isobutyl ketone	240.51 (<0.1%)	0.51 (<0.1%)	0.51 (<0.1%)
Methylene chloride	241.8 (0.3%)	1.8 (0.3%)	1.82 (0.4%)
Napthalene	240.01 (<0.1%)	0.01 (<0.1%)	0.01 (<0.1%)
Phenol	240.03 (<0.1%)	0.03 (<0.1%)	0.03 (<0.1%)

Table 5-31. (continued).

Emissions	Averaging Time	Alternatives 1 through 4 Option a Dry Storage	Option b Wet Storage	Option c Processing
Phosphorus		24<0.001 (<0.2%)	<0.001 (<0.2%)	<0.001 (<0.2%)
Sodium hydroxide		240.01 (<0.1%)	0.01 (<0.1%)	0.01 (<0.1%)
Toluene		241.6 (8%)	1.6 (8%)	2.0 (10%)
Trichloroethene		241.0 (0.3%)	1.0 (0.3%)	1.0 (0.3%)
Vinyl acetate		240.02 (<0.1%)	0.02 (<0.1%)	0.02 (<0.1%)
Xylene		243.81 (<0.1%)	3.81 (<0.1%)	3.85 (<0.1%)

Alternative 5 - Centralization

Emissions	Averaging Time	Option 5a Dry Storage	Option 5b Wet Storage	Option 5c Processing	Option 5d Ship Out
Criteria Pollutants					
NOx		Ann4 (4%)	4 (4%)	15.1 (15%)	4 (4%)
SOx		Ann10 (12%) 24-185.0 (50%) 3-h634.5 (49%)	10 (12%) 185.0 (50%) 634.5 (49%)	10 (12%) 185.5 (52%) 637.5 (49%)	10 (12%) 185.0 (50%) 634 (49%)
PM10		Ann3 (6%) 24-56.0 (37%)	3 (6%) 56.0 (37%)	3 (6%) 56.4 (38%)	3 (6%) 56.0 (37%)
TSP		Ann11 (17%)	11 (17%)	11 (17%)	11 (17%)
Ozone (as VOC)		1-hN/Ad	N/Ad	N/Ad	N/Ad
Gaseous fluoride (as HF)		1-m0.03 (4%) 1-w0.15 (9%) 24-0.31 (11%) 12-0.62 (17%)	0.03 (4%) 0.15 (9%) 0.31 (11%) 0.62 (17%)	0.05 (6%) 0.25 (16%) 0.41 (14%) 1.02 (28%)	0.03 (4%) 0.15 (9%) 0.31 (11%) 0.62 (17%)
Lead		Ann<0.01 (<1%)	<0.01 (<1%)	<0.01 (<1%)	<0.01 (<1%)
CO		8-h24 (0.2%) 1-h187 (0.5%)	24 (0.2%) 187 (0.5%)	28.1 (0.3%) 217 (0.5%)	23.1 (0.2%) 181 (0.4%)
Toxic Pollutants					
Nitric acid		24-6.7 (5%)	6.7 (5%)	7.7 (6%)	6.7 (5%)
1,1,1-Trichloroethane		24-22 (0.2%)	22 (0.02%)	22 (0.2%)	22 (0.2%)
Benzene		24-31 (21%)	31 (21%)	31 (21%)	31 (21%)

Emissions	Averaging Time				
Ethanolamine	24-	<0.01 (<0.1%)	<0.01 (<0.1%)	<0.01 (<0.1%)	<0.01 (<0.1%)
Ethylbenzene	24-	0.12s (<0.1%)	0.12 (<0.1%)	0.12 (<0.1%)	0.12 (<0.1%)
Ethylene glycol	24-	0.08s (<0.1%)	0.08 (<0.1%)	0.08 (<0.1%)	0.08 (<0.1%)
Formaldehyde	24-	<0.01 (<0.1%)	<0.01 (<0.1%)	<0.01 (<0.1%)	<0.01 (<0.1%)
Glycol ethers	24-	<0.01 (N/A)	<0.01 (N/A)	<0.01 (N/A)	<0.01 (N/A)
Hexachloronaphthalene	24-	<0.01 (<1%)	<0.01 (<1%)	<0.01 (<1%)	<0.01 (<1%)

Table 5-31. (continued).

Emissions	Averaging Time	Alternative 5 - Centralization			
		Option 5a Dry Storage	Option 5b Wet Storage	Option 5c Processing	Option 5d Ship Out
Hexane	24-	0.07s (<0.1%)	0.07 (<0.1%)	0.11 (<0.1%)	0.07 (<0.1%)
Manganese	24-	0.10 (0.4%)	0.10 (0.4%)	0.10 (0.4%)	0.10 (0.4%)
Methanol	24-	0.51s (<0.1%)	0.51 (<0.1%)	0.51 (<0.1%)	0.51 (<0.1%)
Methyl ethyl ketone	24-	0.99s (<0.1%)	0.99 (<0.1%)	0.99 (<0.1%)	0.99 (<0.1%)
Methyl isobutyl ketone	24-	0.51s (<0.1%)	0.51 (<0.1%)	0.51 (<0.1%)	0.51 (<0.1%)
Methylene chloride	24-	1.8 (0.3%)	1.8 (0.3%)	1.82 (0.4%)	1.8 (0.3%)
Napthalene	24-	0.01s (<0.1%)	0.01 (<0.1%)	0.01 (<0.1%)	0.01 (<0.1%)
Phenol	24-	0.03s (<0.1%)	0.03 (<0.1%)	0.03 (<0.1%)	0.03 (<0.1%)
Phosphorus	24-	<0.001 (<0.2%)	<0.001 (<0.2%)	<0.001 (0.2%)	<0.001 (<0.2%)
Sodium hydroxide	24-	0.01s (<0.1%)	0.01 (<0.1%)	0.01 (<0.1%)	0.01 (<0.1%)
Toluene	24-	1.6 (8%)	1.6 (8%)	2.0 (10%)	1.6 (8%)
Trichloroethene	24-	1.0 (0.3%)	1.0 (0.3%)	1.0 (0.3%)	1.0 (0.3%)
Vinyl acetate	24-	0.02s (<0.1%)	0.02 (<0.1%)	0.02 (<0.1%)	0.02 (<0.1%)
Xylene	24-	3.81s (<0.1%)	3.81 (<0.1%)	3.85 (<0.1%)	3.81 (<0.1%)

a. Source: WSRC (1994a).
b. Numbers in parentheses indicate the percentage of the regulatory standard that each concentration represents.
c. No standard for this chemical.
d. Measurement data currently unavailable.

The data demonstrate that, even with the emissions from the spent nuclear fuel management activities, releases of toxic air pollutants from the SRS would be only a small fraction of the regulatory standards. Therefore, DOE anticipates no cumulative impact.

The releases of some criteria air pollutants by SRS operations would approach regulatory standards. Site sulfur dioxide emissions would reach about 50 percent of both the 24-hour and 3-hour limits under all alternatives. In addition, the emissions of particulates less than 10 microns (PM10) would approach a concentration equal to about 38 percent of the standard. However, the contribution to both these pollutants concentrations made by spent nuclear fuel-related activities would be small, as explained in Section 5.7.

The SRS evaluated the cumulative impact of airborne radioactive releases in terms of cumulative dose to a maximally exposed individual at the Site boundary. Table 5-32 lists the results of this

Table 5-32. Annual cumulative health effects to workers and offsite population due to SRS radioactive releases during incident-free operations.

	Worker				Offsite Population			
	Average Individual		Total Collective		Maximally Exposed Individual		Total Collective	
	Dosea	Fatal Cancerb	Dosec	Fatal Cancersd	Dosea	Fatal Cancerb	Dosec	Fatal Cancersd
Alternative 1 - No Action								
Option 1 Wet Storage	3.2x10-1	1.3x10-4	9.4x101	3.7x10-2	9.0x10-5	4.5x10-8	8.9x100	4.4x10-3
Alternative 2 - Decentralization								
Option 2a Dry Storage	3.0x10-1	1.2x10-4	9.4x101	3.7x10-2	9.0x10-5	4.5x10-8	8.9x100	4.4x10-3

Option 2b Wet Storage	3.2x10-1	1.3x10-4	9.4x101	3.7x10-2	9.0x10-5	4.5x10-8	8.9x100	4.4x10-3
Option 2c Processing	3.6x10-1	1.5x10-4	1.6x102	6.5x10-2	4.4x10-4	2.2x10-7	2.6x101	1.3x10-2
Alternative 3 - 1992/1993 Planning Basis								
Option 3a Dry Storage	3.0x10-1	1.2x10-4	9.4x101	3.7x10-2	9.0x10-5	4.5x10-8	8.9x100	4.4x10-3
Option 3b Wet Storage	3.2x10-1	1.3x10-4	9.4x101	3.7x10-2	9.0x10-5	4.5x10-8	8.9x100	4.4x10-3
Option 3c Processing	3.7x10-1	1.5x10-4	1.6x102	6.6x10-2	4.5x10-4	2.2x10-7	2.6x101	1.3x10-2
Alternative 4 - Regionalization								
Option 4a Dry Storage	3.0x10-1	1.2x10-4	9.4x101	3.7x10-2	9.0x10-5	4.5x10-8	8.9x100	4.4x10-3
Option 4b Wet Storage	3.2x10-1	1.3x10-4	9.4x101	3.7x10-2	9.0x10-5	4.5x10-8	8.9x100	4.4x10-3
Option 4c Processing	3.7x10-1	1.5x10-4	1.7x102	6.8x10-2	4.7x10-4	2.3x10-7	2.7x101	1.4x10-2
Option 4d Dry Storage	3.2x10-1	1.3x10-4	9.4x101	3.7x10-2	9.0x10-5	4.5x10-8	8.9x100	4.4x10-3
Option 4e Wet Storage	3.5x10-1	1.4x10-4	9.4x101	3.7x10-2	9.0x10-5	4.5x10-8	8.9x100	4.4x10-3
Option 4f Processing	4.0x10-1	1.6x10-4	1.7x102	6.8x10-2	4.7x10-4	2.3x10-7	2.6x101	1.3x10-2
Option 4g Ship Out	<3.2x10-1	<1.3x10-4	<9.4x101	<3.7x10-2	<9.0x10-5	<4.5x10-8	<8.9x100	<4.4x10-3

Table 5-32. (continued).

	Worker				Offsite Population			
	Average Individual		Total Collective		Maximally Exposed Individual		Total Collective	
	Dose[a]	Fatal Cancers[b]	Dose[c]	Fatal Cancers[d]	Dose[a]	Fatal Cancers[b]	Dose[c]	Fatal Cancers[d]
Alternative 5 - Centralization								
Option 5a Dry Storage	1.3	5.3x10-4	9.6x101	3.8x10-2	9.0x10-5	4.5x10-8	8.9x100	4.4x10-3
Option 5b Wet Storage	1.6	6.4x10-4	9.6x101	3.8x10-2	9.0x10-5	4.5x10-8	8.9x100	4.4x10-3
Option 5c Processing	1.6	6.6x10-4	1.7x102	6.9x10-2	4.7x10-4	2.3x10-7	2.7x101	1.4x10-2
Option 5d Ship Out	<3.2x10-1	<1.3x10-4	<9.4x101	<3.7x10-2	<9.0x10-5	<4.5x10-8	<8.9x100	<4.4x10-3

a. Dose in rem.
b. Probability of fatal cancer.
c. Dose in person-rem.
d. Incidence of excess fatal cancers.

analysis. The highest dose would be 4.7x10-1 millirem, which would occur under the processing options of Alternatives 4 and 5. This dose is below the regulatory standard (CFR 1994) of 10 millirem.

Airborne emissions from the two-unit Vogtle Electric Generating Plant (approximately 10 miles southwest of the center of the SRS near Waynesboro, Georgia) were reported to have delivered an MEI total body dose of 1.14 x 10-3 millirem during 1992 (Georgia Power Company 1993). Since the SRS and Plant Vogtle are essentially proximal to the same 80 kilometer population, the ratio of SRS population and MEI doses was used as an estimator of the population dose due to Plant Vogtle emissions. Using this approach, the population dose attributable to Vogtle was estimated to have been about 8.3 x 10-2 person-rem in 1992. Adding (1) the population dose from Plant Vogtle, (2) the total collective offsite population dose from all SRS activities in 1992 (both air and water source terms), and (3) the highest projected collective dose from spent nuclear fuel management activities (Options 4c and 5c) yields a total cumulative dose of 27.083 person-rem from all SRS sources and Plant Vogtle, which is only 0.3 percent higher than the dose from SRS alone. Note that the doses in Table 5-32 ("Total Collective Dose, Offsite Population") represent the sum of (2) and (3) above.

5.16.4 Water Resources

Approximately 82.1 million gallons per year of Savannah River water would be required for the two most water-intensive options, Option 4f (Regionalization at SRS - Processing) and Option 5c (Centralization - Processing). Because either of these options would probably require construction of an Expended Core Facility, this facility's projected surface water usage of 2.5 million gallons per year was factored into the cumulative impacts analysis. Thus, the two options with the highest surface water usage, both of which would require as much as 84.6 million gallons, represent approximately 0.4 percent of the current (baseline) SRS surface water usage of 20 billion gallons per year (see Table 5-8).

Operational impacts to surface water quality under any of the spent nuclear fuel management options examined would be minimal. Existing SRS treatment facilities could accommodate all new spent nuclear fuel-related domestic and process wastewater streams. Expected wastewater flows would be well within the design capacities of existing (or planned upgrades of) Site treatment systems. Sanitary wastewater from new spent nuclear fuel facilities would be routed to the new Centralized Sanitary Wastewater Treatment Facility. Liquid radioactive wastes would presumably be sent to the F-/H-Area Effluent Treatment Facility. Treated nonradioactive liquid releases from the new spent nuclear fuel facilities would likely be discharged to Upper Three Runs Creek or Fourmile Branch.

Water quality in the Savannah River downstream of the SRS is adequate to good, with most parameters analyzed showing values below state and Federal Maximum Contaminant Levels or DOE Derived Concentration Guides. Iron, present in soils in the region, is the only constituent of surface waters that routinely exceeds MCLs. Spent nuclear fuel management activities are not expected to result in higher concentrations of iron downstream of the SRS. As noted earlier, in Section 5.16, construction on the new Centralized Sanitary Wastewater Treatment Facility is scheduled to begin in 1994 and should be completed in 1995. The new Centralized Sanitary Wastewater Treatment Facility will replace 14 aging sanitary wastewater facilities with a single state-of-the-art facility which will treat sanitary wastes by an extended aeration-activated sludge process. Chlorine will not be used to treat sanitary wastes in the new facility. Use of non-chemical ultraviolet light disinfection systems will eliminate the use and handling of 32,000 gallons of sodium hypochlorite and 59,000 gallons of sodium sulfite per year. Eliminating these chemicals will essentially eliminate the potential for toxic chemical releases from the wastewater treatment process.

Operation of the new Centralized Sanitary Wastewater Treatment Facility and closure of the old A-, B-, S-Area, and Naval Fuel sanitary wastewater facilities would also eliminate wastewater discharges to Upper Three Runs Creek, the stream on the SRS least degraded by past operations. Treated effluent from the new Centralized Sanitary Wastewater Treatment Facility will discharge to Fourmile Branch. Overall stream quality in Fourmile Branch is expected to improve because the effluent from the new facility will be cleaner than the effluent from the old package plants in C-, F-, and H-Areas that presently discharge to Fourmile Branch. As a result, the cumulative effect of the new spent nuclear fuel management facilities (any alternative considered) and new Centralized Sanitary Wastewater Treatment Facility will probably be a net improvement in water quality in two SRS streams, Upper Three Runs Creek and Fourmile Branch, and may result in better water quality downstream in the Savannah River as well.

Sanitary wastewater from the new Consolidated Incineration Facility will be routed to the new Centralized Sanitary Wastewater Treatment Facility; there will be no direct process wastewater drains to the environment. Liquid wastes will be collected in storage tanks and periodically trucked to a permitted hazardous/mixed waste treatment and disposal facility. Sanitary wastes from the new Savannah River Ecology Laboratory Conference Center will be piped to a septic tank-drain field system and would not impact surface water in the area.

Sanitary wastes produced during construction of the Expended Core Facility would be treated through the use of portable chemical toilets or through an existing wastewater treatment facility. Depending on the location chosen by DOE and the Navy for the new Expended Core Facility, sanitary wastes from operation of the ECF would either be treated in an existing wastewater treatment facility (most likely the new Centralized Sanitary Wastewater Facility) or a new treatment facility designed to handle the facility's wastewater capacity. No process wastes from operation of the Expended Core Facility will be discharged to the environment.

5.16.5 Occupational and Public Health and Safety

Table 5-32 summarizes the cumulative health effects of incident-free SRS operations, including those projected for the spent nuclear fuel alternatives. The table lists potential cancer fatalities for workers and the public due to radiological exposures to airborne and waterborne releases from the Site. In addition, the table provides the (airborne) dose to the hypothetical maximally exposed individual in the offsite population. The evaluation used 1992 as the baseline year for normal operations, because it is the last year for which the SRS has complete information. DOE believes that this year gives a realistic depiction of current operational releases of radionuclides. The assessment added the estimated releases from each spent fuel alternative to this baseline to determine the cumulative impacts listed in Table 5-32.

5.16.6 Waste Management

The analysis of cumulative impacts of SRS waste management activities takes as its starting point the assumption that waste generation under the No Action Alternative represents the baseline condition for the entire Savannah River Site. Waste generation levels associated with the other proposed spent nuclear fuel management alternatives (see Table 5-19) thus represent positive and negative deviations from this baseline. Cumulative effects of the proposed spent nuclear fuel alternatives on the volume of low-level waste, transuranic waste, and high-level waste produced under each of the proposed alternatives are presented in Table 5-30.

In addition to baseline waste generation and wastes generated by spent nuclear fuel management activities, environmental restoration and cleanup activities are expected to become an increasingly important part of the DOE mission at the SRS in the future. These remediation activities are expected to produce large quantities of radioactive, hazardous, and mixed wastes. It is estimated that approximately 22,000 cubic meters (28,754 cubic yards) of low-level waste, 366,000 cubic meters (478,362 cubic yards) of hazardous waste, 82,000 cubic meters (107,174 cubic yards) of mixed wastes, and 900 cubic meters (1,176 cubic yards) of transuranic wastes would be produced by environmental restoration activities at the SRS over the 1995-2024 period (DOE 1995). Decontamination and decommissioning activities are expected to generate approximately 109,000 cubic meters (142,463 cubic yards) of low-level waste, 32,000 cubic meters (41,824 cubic yards) of hazardous waste, 95,000 cubic meters (124,165 cubic yards) of mixed wastes, and 4,000 cubic meters (5,228 cubic yards) of transuranic wastes over the same 30-year period (DOE 1995). High-level radioactive waste would not be generated by environmental restoration or decontamination and decommissioning activities.

5.17 Unavoidable Adverse Environmental Impacts

The construction and operation of facilities related to any of the five alternatives at the Savannah River Site (SRS) would result in some adverse impacts to the environment. Changes in project design and other measures could eliminate, avoid, or reduce most of these to minimal levels. The following paragraphs identify adverse impacts that mitigation could not reduce to minimal levels or avoid altogether.

The generation of some fugitive dust during construction would be unavoidable, but would be controlled by water and dust suppressants. This would occur under Alternatives 2 to 5, but greatest generation of dust would occur under Alternative 5 (excluding the offsite shipping option). Similarly, construction activities would result in some minor, yet unavoidable, noise impacts from heavy equipment, generators, and vehicles.

The maximum loss of habitat would involve the conversion of 70 to 100 acres (0.28 to 0.4 square kilometer) of managed pine forest to industrial land use; this would occur under Alternative 5 if DOE moved all spent nuclear fuel to the SRS.

The amount of radioactivity that normal operation of the spent nuclear fuel facilities would release under four of the five alternatives (Alternatives 1 to 4) would be a small fraction of the 1992 operational releases at the SRS and would be well below applicable regulatory standards.

For the alternative having the most impact (Alternative 5 - Centralization), DOE has calculated that the maximum probability for latent fatal cancer for the maximally exposed member of the public would be about 3 times higher than that calculated for 1992 at the SRS. For latent fatal cancer incidence in the offsite population, this comparison indicates an increase of about 2 times, but the number of cancers calculated is less than one.

The only socioeconomic impacts of the proposed spent nuclear fuel management facilities would be temporary increases in employment and expenditures in the region of influence during the construction phase. These would be unavoidable beneficial impacts.

5.18 Relationship Between Short-Term Use of the Environment and the

Maintenance and Enhancement of Long-Term Productivity

Implementation of any of the proposed alternatives would result in some short-term resource demands (e.g., fuel, construction materials, and labor) and would, under certain alternatives (notably the Centralization Alternative), reduce the natural productivity of a relatively small tract of land (less than .07 percent of total SRS area) currently committed to timber production. Depending upon the precise location selected for facility development, a small amount of marginal-to-good wildlife habitat (see Sections 4.9 and 5.9) would also be lost when the area is cleared, graded, and committed to facilities and supporting infrastructure. However, these short-term resource losses and land-use restrictions provide a basis for improved productivity and utility over the long term at the SRS because consolidating all spent nuclear fuel at a few onsite locations would free for other uses those locations presently committed to spent fuel management. On a national scale, the interim management plan described in this EIS would have the same impact of making locations throughout the DOE complex available for other long-term uses.

5.19 Irreversible and Irretrievable Commitments of Resources

The irreversible and irretrievable commitment of resources resulting from the construction and operation of facilities related to the spent nuclear fuel alternatives would involve materials that could not be recovered or recycled or that would be consumed or reduced to unrecoverable forms. The construction and operation of spent nuclear fuel facilities at the SRS would consume irretrievable amounts of electrical energy, fuel, concrete, sand, gravel, and miscellaneous chemicals. Other resources used in construction would probably not be recoverable. These would include finished steel, aluminum, copper, plastics, and lumber. Most of this material would be incorporated in foundations, structures, and machinery. Construction and operation of facilities for spent nuclear fuel management would also require the withdrawal of water from surface- and groundwater sources, but most of this water would return to onsite surface streams or the Savannah River after use and treatment.

The Centralization alternative (Option 5c - Processing) would consume the greatest amount of electricity of any of the alternatives, about 110,400 megawatt-hours. The Processing option (excluding Option 4c, Regionalization by fuel type) would have the highest requirements for coal to produce steam, approximately 2,580 metric tons (2,843 tons) annually. The Centralization alternative (except Option 5d where all spent fuel would be shipped off the site) would involve the greatest irretrievable consumption of other resources, such as construction materials, chemicals, gases, and operating supplies. However, this demand would not constitute a permanent drain on local resources or involve any material that is in short supply in the region.

5.20 Potential Mitigation Measures

This section summarizes measures that DOE could use to avoid or reduce impacts to the environment caused by spent nuclear fuel management activities at the SRS. DOE would determine the extent to which any mitigation would be necessary and the selection of which measures would be implemented during a detailed site-specific NEPA review tiered from this Programmatic EIS. Consequently, the following sections in this chapter address impact avoidance and mitigation in general terms and describe typical measures that the SRS could implement. In addition, the analyses described in this appendix indicate that the environmental consequences of spent fuel management would be minimal in most environmental media.

5.20.1 Pollution Prevention

DOE is committed to comply with Executive Order 12856, "Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements"; Executive Order 12780, "Federal Acquisition, Recycling and Waste Prevention"; and applicable DOE Orders and Guidance Documents in planning and implementing pollution prevention at the SRS. The pollution prevention program at the Site was initiated in 1990 as a waste minimization program. Currently, the program consists of four major initiatives: solid waste minimization; source reduction and recycling of wastewater discharges; source reduction of air emissions; and potential procurement of products manufactured from recycled materials. Since 1991, the waste of all types generated at the SRS has decreased, with greatest reductions in hazardous and mixed wastes. These reductions are attributable primarily to material substitutions.

All spent fuel management activities at the SRS would be subject to the Site pollution prevention program. Implementation of the program plan would minimize the amount of waste generated by these activities.

5.20.2 Socioeconomics

Spent nuclear fuel activities would have minimal impact on the socioeconomic environment in the region of influence because most employees would be drawn from the existing site workforce. The minor impacts of in-migrating construction workers could be minimized by DOE possibly informing local communities and county planning agencies as to scheduling of construction activities.

5.20.3 Cultural Resources

A Programmatic Memorandum of Agreement (SRARP 1989) between the DOE Savannah River Operations Office, the South Carolina State Historic Preservation Office, and the Advisory Council on Historic Preservation, ratified on August 24, 1990, is the instrument for the management of cultural resources at the SRS. DOE uses this memorandum to identify cultural resources and develop mitigation plans for affected resources in consultation with the State Historic Preservation Officer. DOE would comply with the terms of the memorandum for all measures needed to support spent nuclear fuel management at the Site. For example, DOE would survey sites prior to disturbance and could reduce impacts to any potentially-significant cultural resources discovered through avoidance or removal. Any artifacts discovered would be protected from further disturbance and the elements until removed.

DOE conducted an investigation of Native American concerns over religious rights in the Central Savannah River Valley in conjunction with studies in 1991 related to a New Production Reactor. During this study, three Native American groups expressed concern over sites and items of religious significance on the SRS (see Section 4.4.2). DOE has included these organizations on its environmental mailing list, solicits their comments on NEPA actions of the Site, and sends them documents about SRS environmental activities, including those related to these SNF management considerations. These Native American groups would be consulted on any actions that may follow subsequent site-specific environmental reviews.

5.20.4 Geology

DOE expects that there would be no impacts to geologic resources at the SRS under any alternative evaluated in this EIS. Potential soil erosion in areas of ground disturbance would be minimized through sound engineering practices such as implementing controls for stormwater runoff (e.g., sediment barriers), slope stability (e.g., rip-rap placement), and wind erosion (e.g., covering soil stockpiles). Re-landscaping would minimize soil loss after construction was completed. These measures would be included in a site-specific Storm Water Pollution Prevention Plan that the SRS would prepare prior to initiating any construction.

5.20.5 Air Resources

DOE would meet applicable standards and permit limits for all radiological and non-radiological releases to the atmosphere. In addition, the SRS would follow the DOE policy of maintaining radiological emissions to levels "as low as reasonably achievable" (ALARA). ALARA is an approach to radiation protection to control or manage exposures (both individual and collective) and releases of radioactive material to the environment as low as social, technical, economic, practical, and public policy considerations permit. ALARA is not a dose limit, but rather a process that has as its objectives the attainment of dose levels as far below the applicable limits as practicable.

5.20.6 Water Resources

DOE would minimize the potential for adverse impacts on surface water during construction through the implementation of a stormwater pollution prevention plan that details controls for erosion and sedimentation. The plan would also establish measures for prevention of spills of fuel and chemicals and for rapid containment and cleanup.

DOE could minimize water usage during both construction and operation of facilities by instituting water conservation measures such as instructing workers in water conservation (e.g., turn off hoses when not in use), installing flow restrictors, and using self-closing hose nozzles.

5.20.7 Ecological Resources

DOE does not anticipate that any of the spent fuel alternatives would impact any wetlands on the Site. In any case, DOE and SRS policy is to achieve "no net loss" of wetlands. Pursuant to this goal, DOE has issued a guidance document, Information for Mitigation of Wetlands Impacts at the Savannah River Site (DOE 1992), for project planners that puts forth a practical approach to wetlands protection that begins with avoidance of impacts (if possible), moves to minimization of impacts (if avoidance is impossible), and requires compensatory measures (wetlands restoration, creation, or acquisition) in the event that impacts cannot be avoided.

The analysis in this EIS indicates that there are no threatened and endangered species or sensitive habitats in the areas considered as representative of potential sites for spent nuclear fuel activities at the SRS. However, DOE would perform site-specific predevelopment surveys to ensure that development of new facilities would not impact any of these biological resources.

5.20.8 Noise

DOE anticipates that noise impacts both on and off the Site would be minimal. DOE does not foresee noise impacts from spent nuclear fuel management that would warrant mitigation measures beyond those consistent with good construction, engineering, operations, and management practices.

5.20.9 Traffic and Transportation

DOE has a system of onsite buses operating at the SRS. The Site would evaluate the need for upgrades or changes in service that might be required for the spent nuclear fuel management activities and would make changes, as necessary.

DOE would manage changes in traffic volume or patterns during construction through such measures as designating routes for construction vehicles, providing workers with safety reminders, and upgrading onsite police traffic patrols, if necessary.

5.20.10 Occupational and Public Health and Safety

The DOE program for maintaining radiological emissions to levels "as low as reasonably achievable" (ALARA) described in Section 5.20.5 above will minimize any impacts to workers and the public due to atmospheric releases. Likewise, the Site Pollution Prevention Plan and emergency preparedness measures will enhance safety both on and off the Site.

5.20.11 Utilities and Support Services

The utilities and support services at the SRS are sufficient to meet the requirements of any of the alternatives for the spent fuel management at the Site. Impacts on these services would be minimal. No mitigation measures would be required.

5.20.12 Accidents

The SRS has in place emergency action plans that would be activated in the case of an accident. These plans contain both onsite provisions (e.g., evacuation plans, response teams, medical and fire response, training and drills, communications equipment) and offsite arrangements (e.g., response plans for medical and fire agencies, coordination with local and state agencies, communication plans). The SRS plans would be updated to include any new facilities or activities related to spent nuclear fuel management that would involve the Site. The execution of the plans in response to an accident would mitigate adverse effects both on the Site and in the surrounding areas.

ATTACHMENT A: ACCIDENT ANALYSIS

ATTACHMENT A: ACCIDENT ANALYSIS

A.1 Accident Evaluation Methodologies and Assumptions

The potential for facility accidents and the magnitude of their consequences is an important factor in the evaluation of the spent nuclear fuel alternatives addressed in this EIS. There are two health risk issues:

- Would accidents at any of the Savannah River Site (SRS) facilities that the U.S. Department of Energy (DOE) could build for spent nuclear fuel management activities pose unacceptable health risks to workers or the general public?
- Could alternative locations or facilities for the spent nuclear fuel alternatives provide smaller public or worker health risks? Smaller risks could arise from such factors as greater isolation of the facility from the public, a reduced frequency of such external accident initiators as seismic events or aircraft crashes, reduced inventory, and process differences.

Guidance for the implementation of Council on Environmental Quality (CEQ) regulations (CFR 1986), as amended (51 FR 15625), requires the evaluation of impacts that would have a low probability of occurrence but high consequences if they did occur; this EIS, therefore, addresses facility accidents to the extent feasible.

A.1.1 Radiological Accident Evaluation Methodology

The alternatives considered in this EIS provide an opportunity to incorporate new features and technology in new facilities, processes, and operations that would minimize the possibility of undue risk to the health and safety of plant workers and the public. Modifications and upgrades would mitigate accident consequences from existing facilities or reduce the likelihood of occurrence.

Under normal circumstances, DOE would develop accident scenarios and calculate accident consequences using safety analyses, mitigation features, and design details on proposed facility designs. However, the preliminary design information for the proposed facilities that is available during the preparation of this EIS does not contain sufficient detail to permit quantitative safety analyses. Therefore, for each spent nuclear fuel alternative, DOE has evaluated the existing and proposed facilities for the type of radiological accidents it has determined to be reasonably foreseeable.

The radiological accident types fell into four categories: (1) fuel damage, (2) material releases, (3) nuclear criticalities, and (4) liquid spills or discharges. For each accident type, DOE determined reference accidents by examining DOE-approved safety analysis reports (SARs) and other appropriate documentation (e.g., previous EISs). In addition, DOE considered accidents from adjacent facilities for their possible impacts related to spent nuclear fuel. DOE extracted the overall frequency for each reference accident from the appropriate source, rather than attempting to calculate individual frequencies for all possible initiators; that is, DOE did not use the specific probability of a certain magnitude earthquake to determine the frequency of a criticality or spill, given the occurrence of the earthquake. If multiple initiators could lead to one of the reference accidents, or the combined frequency of the initiators could lead to one of the reference accidents, DOE used the combined frequency of the initiators, generally providing conservative results. For example, the Receiving Basin for Offsite Fuel has a number of potential release initiators that could result in an uncontrolled criticality, as listed in Table A-1. As listed, a number of incidents, all of which have their own assigned frequencies, can contribute to the initiation of an uncontrolled criticality.

Table A-1. Potential release initiators at the Receiving Basin for Offsite Fuel.

Natural Phenomena	External Events	Operations Induced Events	Criticality
Temperature Extreme	Aircraft Crash	Fuel Cutting	Fuel Bundling Error
Snow	Helicopter Crash	Spill at Hose Rack	Cask Loading Error
Rain	Surface Vehicle Crash	Fuel Rupture in Storage	Fuel Identification Problem
Lightning		Fire and Explosion	Fuel Movement Error
Tornado		Fuel Near Basin Surface	Dropped Fuel
Earthquake		Spills and Leaks	Crane or Hoist Collapse
Meteorite Impact		Resin Regeneration	Cask Immersion Error
		Facility Waste to Cell	

This evaluation results in qualitative comparisons for proposed facilities based on the assumption that the facility function is similar to one already analyzed. In addition, an identical set of initiators is not considered in each safety analysis report for existing SRS facilities because these reports were prepared over several years in accordance with requirements in effect at the time. Section A.2 includes a comparison of the similarities of possible facilities to an existing facility, the basis for the selection of reference accidents, and several tables containing data to support a comparison of point estimates of risk.

The qualitative comparison supports the National Environmental Policy Act (NEPA) process, in that the decisionmaker can assess the relative risk from each alternative at SRS and other sites.

A.1.1.1 Notable Accident Initiators. While there are many different types of accident initiators of various frequencies that could lead to an accident, three notable initiators - criticalities, earthquakes, and aircraft crashes - require additional discussion due to the public's perception of the importance of these initiators and the public's familiarity with these types of initiators.

Because there has never been an uncontrolled criticality accident at the SRS, DOE must use historic experience related to the initiators to estimate the frequency for a criticality incident in the Receiving Basin for Offsite Fuel. Storage basins for spent nuclear fuel have excellent safety histories. From 1945 through 1980, there were 40 known criticality accidents worldwide, none of which occurred in a fuel storage facility. From 1975 to 1980, there were, conservatively, 160 reactors with storage basins in operation around the world, and no criticality incidents occurred. Therefore, DOE assumes that the upper frequency limit for a criticality event is 3.1 x 10-3 per year (Du Pont 1983). This figure is applicable to the extent that the storage basins and the operations performed in them are similar to those of the Receiving Basin for Offsite Fuel. However, the frequency for a processing criticality event was determined through a detailed fault tree analysis, as referenced in the safety analysis report, to be an overall calculated limit of 1.4 x 10-4 per year. This value accounts for the implementation of new administrative controls or equipment.

The SRS is in an area that has a relatively low seismic frequency. Based on three centuries of recorded seismic activity, an earthquake with a Richter magnitude greater than 6.0, which corresponds to a Modified Mercalli Intensity Scale (MMI) of VII, would not be likely at the SRS. The design-basis earthquake for the SRS is a MMI VIII event with a corresponding horizontal peak ground acceleration of 0.2g. Based on current technology, as applied in various probabilistic evaluations of the seismic hazard in the SRS region, the 0.2g peak ground acceleration can be associated with a 2 x 10-4 annual probability of exceedance (5,000-year return period). There are four scenarios for the Receiving Basin for Offsite Fuel to which an earthquake of intensity MMI VIII or greater might contribute:

- Deformation of the storage racks leading to a criticality incident.
- Derailment of the 100-ton (91-metric-ton) crane into the storage basin with the deformation of the storage rack leading to criticality.
- Damage to the basin walls leading to the release of contaminated basin water to the subsoil.
- Rupture of a waste tank or pipe in the Resin Regeneration Facility leading to the release of contaminated liquids.

An aircraft crash into a spent nuclear fuel facility is of concern because it could result in a radioactive release of materials from the stored spent nuclear fuel. Appendix D contains an aircraft crash probability analysis based on the examination of large civilian and military aircraft crossing the airspace within a 10-mile (16-kilometer) radius of the SRS. It does not include the crash probability of general aviation aircraft because aircraft of this type generally do not possess sufficient mass or attain sufficiently high velocities to produce a serious radiological threat in the event that they crashed into an area containing spent nuclear fuel. The analysis did not evaluate crash probabilities with a likelihood of occurrence of less than 10-7 per year because they would not significantly contribute to the risk. This was the case for spent nuclear fuel facilities located at the SRS.

A.1.1.2 Use of DOE-Approved Safety Documents. The NEPA guidance issued by the

DOE Office of NEPA Oversight, dated May 1993, recommends that accident impact analyses "reference Safety Assessments and Safety Analysis Reports, if available." This guidance was the primary basis used to develop the approach used in the accident analysis section of this EIS. This Appendix uses several relevant safety analysis reports as well as a previously published EIS. Safety analysis reports are the primary source of information on reasonably foreseeable accidents with the potential to cause a release of hazardous materials. These reports are required for all reactors and nuclear materials facilities with operations that potentially pose a significant hazard to onsite personnel, offsite populations, or the environment. The referenced safety analysis reports and EIS approval/draft submittal dates encompass a range from 1983 to 1993. The 1983 safety analysis report was supplemented by a 1993 addendum; the next oldest safety analysis report was approved in 1988.

A.1.2 Chemical Hazard Evaluation Methodology

This analysis reviewed the appropriate safety analyses to assess the degree to which they addressed chemical accidents. It found that each of the safety analyses addressed chemical hazards in a qualitative manner. To provide a quantitative discussion of chemical hazards, the analysis evaluated a separate risk assessment (WSRC 1993c) for the storage risk of offsite research reactor fuel in the Receiving Basin for Offsite Fuel to determine a bounding chemical accident. The analysis determined chemical inventories (see Section A.3) for the existing spent nuclear fuel facilities at the SRS using the "Savannah River Site Tier Two Emergency and Hazardous Chemical Inventory Report" (WSRC 1994a) to determine the facilities total chemical inventory. This chemical inventory was further screened using the EPA's "List of Lists" (EPA 1990).

A.1.3 SRS Emergency Plan

The SRS emergency plan (WSRC 1993b) defines appropriate response measures for the management of emergencies (e.g., accidents) involving the Site. It incorporates into one document a description of the entire process designed to respond to and mitigate the consequences of an accident.
Emergencies that could cause activation of all or portions of this plan include:

- Events (operational, transportation, etc.) with the potential to cause releases above allowable limits of hazardous materials.
- Events such as fires, explosions, tornadoes, hurricanes, earthquakes, dam failures, etc.,

that affect or could affect safety systems designed to protect site and offsite populations and the environment.

- Events such as bomb threats, hostage situations, etc., that reduce the security posture of the Site.
- Events created by proximity to other facilities, such as the Vogtle Electric Generating Plant, a commercial nuclear powerplant located across the Savannah River from the Site.

For radiological emergencies, protective actions in this plan are designed to keep onsite and offsite exposures As Low As Reasonably Achievable (ALARA). This is accomplished by minimizing time spent in the vicinity of the hazard, keeping as far from the hazard as possible, and taking advantage of available shielding. Protective actions that could be used on the Site in the event of an emergency include remaining indoors, sheltering, evacuation, and relocation. For events that cause an actual or projected radiological release, appropriate protective actions for on- and offsite populations have been determined based on trigger points called Protective Action Guides (PAGs).

A.1.4 General Assumptions

This assessment applied the following key assumptions to examine existing accident analyses and to relate these analyses to the spent nuclear fuel alternatives.

- When a referenced accident scenario is used for a possible new facility, DOE would build the new facility close to an existing referenced facility performing a similar function, resulting in consequences and health effects similar to the existing facilities analyzed. The exception could be the proposed Expended Core Facility which Appendix D analyzes separately.
- For existing facilities to be modified, portions of the facility to be decommissioned, or new facilities to be added, potential accident initiators resulting from construction and nearby activities would be bounded by the referenced accident scenarios.
- Type 2 High Enriched Uranium fuel, the dominant type currently in storage or process at the SRS, would provide a reference source term for other fuel types (i.e., Mark-22 fuel).
- Spent nuclear fuel acceptance criteria would specify that all fuel must be capable of indefinite suspension in air with no melting.
- The total frequency of an event (e.g., criticality) could be used to determine point estimates of risk, regardless of the type or specific frequencies of the individual contributing initiators.
- Adjustment (scaling) factors could be applied to reflect a best engineering judgment in terms of relative risk between the various alternatives.
- The point estimate of risk for a given accident scenario would be representative in that it could, for the purposes of this programmatic EIS, represent a similar accident scenario at new facilities that perform similar functions.
- Reference accidents would be attributed to a facility based on its function (e.g., fuel canning or dry material storage) regardless of whether the facility currently exists, is undergoing design, or is in the conceptual design phase.
- Possible new facilities would be designed to pose no greater risk to the workers and public than existing facilities with similar functions.

This evaluation takes no credit for the upgraded design requirements for the proposed facilities. Such facilities should have improved reliability or mitigative features and, therefore, would reduce the aggregate frequency of accidents. Therefore, the application of values from existing safety analysis reports would provide conservative results. In addition, the evaluation makes no attempt to discriminate among similar existing facilities that might have slightly different frequencies of occurrence or source terms (i.e., an FB-Line event frequency was applied to HB-Line and other processing facilities).

For most accidents, the evaluation did not quantify consequences for workers. The safety analysis reports from which information was extracted for the reference accidents were written before the issuance of DOE Order 5480.23 (DOE 1992); previous applicable Orders did not require the inclusion of worker doses. The historic record indicates that DOE facilities have an enviable safety record. Figure A-1 compares the rate of worker fatalities in the DOE complex (DOE 1993) to national average rates compiled by the National Safety Council for various industry groups (NSC 1993). Because the DOE worker accident fatality rate compares favorably to rates from such industry groups as agriculture and construction and is slightly less than trade and services group rates, the absence of quantitative data regarding accident impacts to radiological workers should not impede the decisionmaking process. The discussion presented in Volume 1 adequately addresses the impacts for close-in workers (i.e., those directly involved in the activity or near the accident source) at the SRS.

A.1.4.1 Receptor Group Assumptions. To ensure comparative results, the evaluation assessed the measures of impacts among four receptor groups:

- Worker. An individual located 100 meters (328 feet) in the worst sector of a facility location where the release occurs.
- Colocated Worker. An individual located 640 meters (2,100 feet) in the worst sector of a facility location where the release occurs.
- Maximally Exposed Offsite Individual (MEI). A hypothetical resident located at the nearest Site boundary from the facility location where the release occurs.
- Offsite Population to 80 Kilometers. The collective sum of individuals located within an 80-kilometer (50-mile) radius of the SRS.

Figure A-1. Comparison of fatality rates among workers in various industry groups.

As noted above, the worker is 100 meters (328 feet) from the facility where the accident occurs. This is because information quantifying accident impacts (i.e., dose and health effects) to workers at less than 100 meters from an accidental release of radionuclides is unavailable. For each of the accident scenarios considered in Appendix C of this EIS, there is some risk of worker injury or death at distances closer than 100 meters. Furthermore, the safety analyses from which this evaluation extracted information for the accident scenarios often did not include any discussions on worker impacts as a result of potential accidents. DOE Orders published before DOE 5480.23 (DOE 1992) did not require the inclusion of worker doses. However, Section A.2.6.2 includes a qualitative discussion regarding accident impacts for the worker at less than 100 meters (328 feet) for each of the radiological accident scenarios.

A.1.4.2 Code Assumptions. DOE's application of the AXAIR and AXAIR89Q (a validated version) dose estimation models is acceptable for projecting health effects from accidents at SRS and comparing the results to results from other similar codes (RSAC-5 and GENII) used at other sites. AXAIR is a Gaussian model based on the methodology outlined in NRC Regulatory Guide 1.145 (NRC 1983). AXAIR contains a meteorological data file specific to SRS that provides conservative calculated doses for the radiological consequences of atmospheric releases. AXAIR and AXAIR89Q include the following specific functions:

- Performs both environmental transport and radiation dosimetry calculations
- Bases environmental transfer models on NRC Reg Guide 1.145 guidelines
- Includes exposure pathways for inhalation of radionuclides and gamma radiation from the radioactive plume
- Calculates gamma shine doses using a non-uniform Gaussian model
- Uses worst sector and 99.5-percentile meteorology

Doses calculated with this code should bound the radiological consequences for atmospheric releases postulated.

A.1.4.3 Criticality Assumptions. An estimate of the consequences of a criticality incident requires an estimate of the number of fissions that might occur. While U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide 3.34 specifies 1 x 1019 fissions as the upper tenth of incidence experience, the SRS analyses are based on mean values, to the extent possible, for all incidents. Criticality incidents have produced from 1014 to 4 x 1019 fissions with a mean of 2 x 1018 fissions for incidents involving fissile solutions and a mean of 5 x 1017 fissions for incidents involving solids. As a consequence, two accident scenarios (Table A-2) address criticality - the wet pool criticality scenario and the processing criticality scenario. For the wet pool criticality scenario, the mean value for solid systems (5 x 1017) is assumed to apply to the source term used to determine the accident consequences, while the processing criticality scenario assumes that the mean value for a solution

(2 x 1018) was applied to the source term to determine accident consequences.

A.2 Radiological Accident Scenarios

A.2.1 Selection of Reference Accidents

To support the examination of both existing and proposed facilities, this evaluation considered a spectrum of potential accident types. To develop a meaningful spectrum of potential accidents, the evaluation posed the following question:

> "What could be done to spent nuclear fuel that would result in a radiological consequence to the receptor groups?"

In determining the answer to this question, the following four general types of events emerged: (1) fuel damage, (2) material releases, (3) criticalities, and (4) liquid spills or discharges. A review of applicable safety analysis reports for the SRS facilities that the spent nuclear fuel alternatives would be likely to affect generated more than 20 accidents involving the transport, receipt, processing, and storage of spent nuclear fuel. A consolidation and subsequent "binning" of these accidents for each accident type reflects an appropriate range of case-specific reference accidents.

Table A-2. Reference radiological accidents considered for spent nuclear fuel activities.

Name and Reference	Reference for Source Term/Dose	Comparative Likelihood/Frequency
A1. Fuel Assembly Breach Reference Accident: RBOF fuel cutting	Tables 1-3 DPSTSA-200-10-3, Addendum 1	1.6x10-1 per year
A2. Material Release (Processing) Reference Accident: F-Canyon Uncontrolled Reaction	Meehan 1995	2.6x10-1 per year
A3. Material Release (Dry Vault) Reference Accident: PSF release	Table 5-9 DPSTSA-200-10-19	1.4x10-3 per year
A4. Material Release (Adjacent Facility) Reference Accident: Release of Waste Tank Activity to Cell	Tables 1-3 DPSTSA-200-10-3, Addendum 1	2.4x10-3 per year
A5. Criticality in Water Reference Accident: RBOF criticality	Tables 1-3 DPSTSA-200-10-3, Addendum 1	3.1x10-3 per year
A6. Criticality During Processing Reference Accident: FB-Line	WSRC-RP-93-1102	1.4x10-4 per year
A7. Spill/Liquid Discharge (External) Reference Accident: Direct discharge of water from K-Reactor disassembly basin	Figure 3 Meehan 1994	2.0x10-4 per year
A8. Spill/Liquid Discharge (Internal) Reference Accident: RBOF hose rack spill	Tables 1-3 DPSTSA-200-10-3, Addendum 1	1.1x10-1 per year

The fuel damage event (type 1 accident) considered was physical damage or breaching of a fuel assembly. Three material (type 2 accidents) releases were considered; they represent releases that could occur during processing from medium energetic events, those that could occur during dry storage of special nuclear materials, and those that could occur from an adjacent facility. Criticality (type 3 accidents) can have different dose impacts and can occur with different frequencies, depending on the physical or chemical characteristics of the material and the surroundings. Two criticality events - in water and during processing - represent these accident scenarios. The evaluation considered a dry criticality accident scenario bounded by the wet pool criticality in terms of frequency and bounded by the processing criticality accident in terms of number of fissions assumed. Two liquid discharges and spills (type 4 accidents) were considered - discharges of pool or basin water assumed to contain tritium, cesium, and other radioactive constituents from the fuel in the pool (external spill), and spills of slightly contaminated liquids inside a facility during fuel handling, spraying, or cask unloading (internal spill).

These eight typical accidents form the set of accidents for the selection of a reference accident. Each type has been assigned an alphanumeric designator, which is listed below and used throughout this document:

- Type 1 - Fuel damage
    - A1 - Fuel assembly breach
- Type 2 - Material releases
    - A2 - Processing release
    - A3 - Dry vault release
    - A4 - Adjacent facility release
- Type 3 - Criticalities
    - A5 - Criticality in water
    - A6 - Criticality during processing
- Type 4 - Liquid discharges and spills
    - A7 - External spill/liquid discharge
    - A8 - Internal spill/liquid discharge

A second review of the safety analyses and the original list of accidents confirmed that each specific accident considered in DOE-approved safety analyses could be represented or bounded by one of the eight "generic" accidents (i.e., a fire could result in material release or an earthquake could result in criticality or liquid release). The use of this approach with documented total frequencies avoids the need for unique identification of all initiating precursor events or their specific probabilities.

A.2.1.1 Externally Initiated Accidents. The accident analysis section of this EIS considered

accident scenarios from external events or adjacent facilities and their potential impacts on direct spent nuclear fuel activities and facilities. Three significant sources of externally induced accident mechanisms were identified as potentially applicable to these facilities and activities: aircraft crashes, adjacent fires, and adjacent explosions. As discussed above, an aircraft crash scenario is not a reasonably foreseeable event within the probability scope of this EIS. For the most part, a fire or explosion in a facility adjacent to the spent nuclear fuel facilities described in Figure 3-2 would not have a significant impact on spent nuclear fuel facilities. However, the screening process determined that a fire and explosion in the Resin Regeneration Facility, located immediately adjacent to the Receiving Basin for Offsite Fuel, could result in the airborne release to the shielded cell and should be included for completeness.

A.2.1.2 Nearby Industrial or Military Facility Accidents. Within a 40-kilometer

(25-mile) radius of the SRS, there are approximately 120 industrial facilities with 25 or more employees (DOE 1990). Four of these facilities are within a 16-kilometer (10-mile) radius of the SRS. Other than those on the SRS, the only major storage facilities within a 40-kilometer radius are the facilities at Chem-Nuclear Systems, Inc., Vogtle Electric Generating Station, and a cluster of natural gas storage tanks near Beech Island. The facilities within a 16-kilometer radius of the SRS boundary are still at least 10 kilometers (6 miles) from the nearest spent nuclear fuel facility, and thus present negligible risk to spent nuclear fuel activities.

A.2.1.3 Common Cause Accident. DOE considered accident scenarios based on a common

cause accident during the screening process. A severe seismic event was the only common-cause initiator identified with the potential to simultaneously impact multiple spent nuclear fuel management facilities at the SRS. A design basis earthquake, which has an estimated acceleration of 0.2g and an annual frequency of 2.0 x 10-4 per year (or one occurrence every 5,000 years), could potentially impact multiple facilities within a single facility area, resulting in the simultaneous release of radioactive and/or toxic materials from these facilities to the environment. It is also considered possible, although probably less likely, than an earthquake of the same magnitude could damage facilities in more than one facility area (e.g., F- and H-Areas; K-, L-, and P-Reactor Disassembly Basins), resulting in simultaneous releases to the environment.

A semi-quantitative evaluation of the cumulative impacts resulting from multiple releases within an area caused by a severe seismic event was performed as part of the accident selection process described in Section A.2.1. A review of the safety analysis reports for the H-Canyon, HB-Line, and Receiving Basin for Offsite Fuels was performed to determine the consequences and risks presented individually by each facility following a design basis earthquake. The risks presented in each safety analysis report were then summed to approximate the risk that would be expected if all of these releases occurred simultaneously from a single seismic initiator. The sum of these risks was compared to the risks of the other accident scenarios presented within the EIS and were found to be bounded by those accidents. A similar evaluation was performed for the spent nuclear fuel-related facilities in the F-Area, and the same conclusion was reached. For the reactor disassembly basins, multiplying the risk from a severe earthquake calculated for the K-Reactor Disassembly basin by three could be considered as the outermost bounding estimate for the three reactor disassembly basins (K-, L-, and P-Reactor Disassembly Basins). This is considered an unrealistic estimate of the cumulative risk because of the extremely conservative assumptions that were made in performing the K-Reactor Disassembly Basin analysis (Meehan 1994). However, even if the risk is increased by a factor of three, it is still considered to be bounded by other accidents already presented within the EIS. Therefore, consistent with the accident methodology described in Section A.2.1, no further analysis of this type of scenario was required. The SRS does maintain emergency plans that would provide protective actions and mitigate consequences that could occur during a common cause accident scenario.

A.2.1.4 Accidents Resulting from Terrorism. DOE considered accident scenarios based

on a terrorist attack or an act of sabotage during the screening process and concluded that any accident resulting from such initiators would be bounded by or similar to the accident scenarios already considered.

A.2.2 Reference Accident Descriptions

DOE established a reference accident for each of the eight generic or typical accidents. The following paragraphs outline the basis for selection of each reference accident by scenario. A reference accident was included if it is analyzed in an SRS safety analysis report that has been approved by the DOE or submitted to DOE for approval as part of the safety basis authorizing operation of a facility, and if the facility is to be utilized as, or is similar in function to, one of the facilities included in the five alternatives and their subordinate cases. For example, the analysis assumed that the Receiving Basin for Offsite Fuel was representative of any spent nuclear fuel wet storage pool. If an accident could occur in any pool, the analysis selected a reference scenario from the Receiving Basin for Offsite Fuel Safety Analysis Report as the reference accident, as listed in Table A-2. The following paragraphs provide the basis for each selection.

- A1. Fuel Assembly Breach - Physical damage to an assembly could occur from dropping, objects falling onto the assembly, or cutting into the fuel part of an assembly. The Receiving Basin for Offsite Fuel Safety Analysis Report (WSRC 1993a) Addendum contains a current analysis of a "fuel cutting accident." The inert, non-uranium-containing extremities of some spent nuclear fuel elements are cut off (cropped) in the repackaging basin before the bundling of the elements. The spent nuclear fuel could be inadvertently cut, causing a release of airborne or high water activity to the work area. Because of the metallic nature of SRS fuel, only a very small fraction of the gases generated in an assembly would be released to the basin water in an accident. Consistent with the safety analysis report, fuel cooled for 90 days is used in the source term for this accident. With foreign research reactor spent nuclear fuel elements, the release of fission product gases would be less than with the Mark-22 fuel assemblies previously considered. The physics of the release of gases from research reactor fuel is similar to SRS fuel because the fuel is constructed in a similar manner. Spent nuclear fuels that could release more fission gases than a Mark-22 fuel assembly would require an Unreviewed Safety Question analysis before the SRS could accept them in the Receiving Basin for Offsite Fuel. Air monitors in this area would warn personnel in the event of an airborne release. The fuel cutting operation involves only one fuel element at a time. This is representative for all cutting and dropping accidents because cracking the cladding would release less than cutting into the fuel itself.

- A2. Material Release (Processing) - The primary activities associated with processing spent nuclear fuel include dissolving the fuel in acid in the F- or H-Area Canyon, separating the radioactive and fissile isotopes, and forming those isotopes into a solid material, either metal or powder. Because of the large volumes of liquid radioactive solution generated during the dissolution process, uncontrolled reactions in the Canyons are the most rapid means of losing control of the material and inadvertently releasing potentially significant quantities of material to the environment. The most common uncontrolled reactions, and those considered in this scenario, include eructations, foaming, boilover, and gassing while dissolving spent fuel. These types of uncontrolled reactions are typically caused by chemical addition errors, procedural errors, or equipment failure. Although uncontrolled reactions can also include deflagrations and explosions (caused by excess hydrogen generation due to radiolytic decay and the presence of an ignition source), these types of events are much less common, and because of their lower frequency, typically present a lower risk to workers and members of the public. In developing this scenario, it was assumed that the uncontrolled reaction causes a large release of material within the Canyon building to the Canyon sumps which results in a greater than normal release of radioactive material through the ventilation system and Canyon exhaust stack. In addition, it was assumed that the uncontrolled reaction occurred in the F-Canyon facility since the exposures resulting from an inadvertent release of plutonium isotopes are expected to bound potential inadvertent releases of uranium isotopes from uncontrolled reactions in the H-Canyon facility.
- A3. Material Release (Dry Vault) - Accident types A1 and A2 cover material releases from fuel handling and processing. In addition, DOE considered a reference accident for vault-type storage. The Plutonium Storage Facility (PSF) Safety Analysis Report (Du Pont 1989) analyzed three medium energetic events (shipping container failure, criticality, and impact-type events) and an earthquake. As discussed above, medium energetic events are accidents that result in release of material from the primary container and have sufficient energy to penetrate the secondary confinement barriers for a short period of time. That report contains a total frequency of these four initiating events and provides one release value. Because the SRS has no long-term spent nuclear fuel dry storage facilities, this evaluation assumes that the Plutonium Storage Facility vault is representative of dry storage facilities, as are the activities and precursor events. A material release from any medium energetic event in the Plutonium Storage Facility was selected as the reference accident for nonprocessing material releases.
- A4. Material Release (Adjacent Facility) - For completeness, DOE considered a reference accident from a facility immediately adjacent to the Receiving Basin for Offsite Fuel (WSRC 1993a). This scenario includes a fire and explosion at the Resin Regeneration Facility in waste tank EP 38 during which the coolant of a received cask, when discharged to the waste tank, results in a flammable or explosive concentration of vapors in the tank. Rupture of the tank by an explosion could release airborne activity to the shielded cell if the accident occurred during one of the projected 150 times per year when regeneration of the portable columns takes place. While a fire and explosion have not occurred in waste tank EP 38, one fire and pressure surge did occur when a shipping cask was being vented. The

spent nuclear fuel remained intact and radionuclides were not released. The incident has been attributed to the ignition of a mixture of hydrogen, oxygen, and air emanating from the cask and created by reaction of hot aluminum fuel with water left in the cask by the shipper.

- A5. Criticality in Water - This scenario assumes that a wet pool storage facility is the most likely to have a criticality in water. The Receiving Basin for Offsite Fuel provides the capability for underwater receipt, handling, and storage of spent nuclear fuel. Primary radiation shielding is provided by the water covering the spent nuclear fuel. A safety analysis report determined frequency and results from many initiating events that could lead to criticality. The following activities could ultimately lead to a criticality incident: Fuel Bundling, Cask Loading, Fuel Identification and Manifest Problems, Fuel Movement, Dropped Fuel, Fuel Near Basin, Cask Immersion, and Cranes and Hoist. These events are representative for any wet storage pool.
- A6. Criticality During Processing - As noted in the discussion for accident type A2, FB-Line events are representative for SRS processing facilities. The analysis considered the total of the frequencies for criticality initiators for all processing stages, which would, therefore, be conservative because not all processing stages would necessarily be involved in a new facility and not all stages would necessarily occur simultaneously.
- A7. Spill/Liquid Discharge (External) - The reference accident selected for this type of event is the direct discharge of water (i.e., 3.4 million gallons) from the K-Reactor disassembly basin to the Savannah River and the exposure of fuel and targets in the basin to air. Analyses performed by the DOE while developing the EIS for the Interim Management of Nuclear Materials at the SRS demonstrate that this scenario could be initiated by a severe earthquake and would result in bounding airborne exposures (from exposed fuel) and liquid exposures (contaminated drinking water) to the general public. The selection of the direct-discharge event is conservative for existing or possible new facilities constructed in the F- or H-Areas because no free-flowing surface streams would be near a discharge point. The use of the source term from the reactor disassembly basin is considered to be conservative for the spent nuclear fuel storage pools since its inventory consists primarily of the fuel types with the largest source terms available for release (i.e., Mark-22 assemblies). Although the disassembly basin has water circulating systems to control radioactivity, chemistry, clarity, and temperature, these processes are less efficient than those used in the Receiving Basin for Offsite Fuel, resulting in higher concentrations of tritium, cesium, and other contaminants available for release.
- A8. Spill/Liquid Discharge (Internal) - DOE considered a second reference accident for contaminated liquids spills or discharges to ensure the appropriate onsite impacts. The discharge discussed for accident type A7 would be external to the building and would have no measurable worker impact component because the reference accident occurred outside the facility. The Receiving Basin for Offsite Fuel hose rack spill was selected as the reference accident because it is representative of small, unplanned, but relatively frequent spills in a storage facility and could impact the worker. Minor releases of contaminated water could occur at the hose rack platform during the handling of portable deionizers for the reactor areas.

A.2.3 Source Term and Frequency Determinations

Table A-2 lists source term references from existing documents approved by DOE or submitted by Westinghouse Savannah River Company to DOE for approval for each selected reference accident. The same references nominally prescribed the frequency of accidents or initiating events. If it was not directly available, the frequency was derived from information already contained in the appropriate safety analysis report or EIS (e.g., if only a risk estimate and a dose were listed, the frequency was derived by dividing the risk by the dose). These frequencies fall into ranges associated with abnormal events (more frequent than 1 x 10-3 per year), design-basis accidents (1 x 10-3 per year to 1 x 10-6 per year), or beyond-design-basis accidents (less than 1 x 10-6 per year to 10-7 per year).

This document does not analyze beyond-design-basis accidents or accidents with frequencies of less than 1.0 x 10-6 explicitly because the accident analysis source material (DOE-approved safety analysis reports) considers these accidents to be incredible events. Beyond-design-basis accidents, such as an airplane crash-induced criticality, have no different consequences (i.e., number of fissions) than the criticality estimated to occur with a frequency of 3.1 x 10-3 per year. Because of the use of aggregate frequencies in some cases, the contribution to overall risk from 1.0 x 10-7 per year events is negligible, and the higher frequency initiators dominate the point estimate of risk. Some initiating or precursor event frequencies from the safety analysis reports are at 10-7 per year or lower; thus, these reports in fact consider events beyond the 10-6 frequencies.

Frequencies for reference accidents were determined as follows:

- A1. Fuel Assembly Breach - The frequency for this reference accident was obtained from DPSTSA-200-10-3, Receiving Basin for Offsite Fuel (RBOF), Addendum 1, Tables 1-5, which lists the frequency as 1.6 x 10-1 per year (WSRC 1993a).
- A2. Material Release (Processing) - The frequency for this reference accident was obtained from DPSTSA-200-10-4, Safety Analysis - 200 Area, Savannah River Plant, F-Canyon Operations, Addendum 2, "Accident Analysis," Revision 1, Table A.5.5-7A, which lists the frequency for an uncontrolled chemical reaction (the bounding processing accident) as 2.6 x 10-1 per year (Meehan 1995).
- A3. Material Release (Dry Vault) - The frequency for this reference accident was obtained from DPSTSA-200-10-19, Final Safety Analysis Report - 200 Area, Savannah River Site Separations Area Operations, Building 221F, B-Line, Plutonium Storage Facility, July 1989, Table 5-9, which lists the frequency as 1.4 x 10-3 per year (Du Pont 1989).
- A4. Material Release (Adjacent Facility) - The frequency for this reference accident was obtained from DPSTSA-200-10-3, Receiving Basin for Offsite Fuel (RBOF), Addendum 1, Tables 1-5, which lists the frequency as 2.4 x 10-3 per year (WSRC 1993a).
- A5. Criticality in Water - The frequency for this reference accident was obtained from DPSTSA-200-10-3, Receiving Basin for Offsite Fuel (RBOF), Addendum 1, Tables 1-5, which lists the frequency as 3.1 x 10-3 per year (WSRC 1993a).
- A6. Criticality During Processing - The frequency for this reference accident was obtained from WSRC-RP-93-1102, FB-Line Basis for Interim Operation, November 1993, Figure 3, which lists a frequency of 1.4 x 10-4 per year (WSRC 1993d).
- A7. Spill/Liquid Discharge (External) - The frequency for this reference accident was derived from analyses provided in DOE/EIS-0147, Continued Operation of K-, L-, and P-Reactors, December 1990 (DOE 1990), as well as other safety analyses developed for additional SRS facilities. The initiating event is a design basis earthquake with peak horizontal ground accelerations equal to 0.2 times the force of gravity (i.e., 0.2g) which occurs with an estimated frequency of 2.0 x 10-4 per year, and results in the release of the basin water (3.4 million gallons) to the Savannah River.
- A8. Spill/Liquid Discharge (Internal) - The frequency for this reference accident was obtained from DPSTSA-200-10-3, Receiving Basin for Offsite Fuel (RBOF), Addendum 1, Tables 1 - 3, which lists the frequency as 1.1 x 10-1 per year for a representative spill at a hose rack (WSRC 1993a).

A.2.4 Applicability of Accidents to Facilities

This evaluation reviewed Section 1 of the reference document Technical Data Summary Supporting the Spent Nuclear Fuel Environmental Impact Statement (WSRC 1994b) to develop a matrix of the selected radiological accidents to the facilities (modules) being considered for the various alternatives and cases. For proposed new facilities, the analysis used best engineering judgment to extrapolate from appropriate accident scenarios based on the descriptions provided in the reference document. Table A-3 lists the connection of facilities to accident scenarios. For example, the Examination and Characterization Facility (module B) identifies a potential accident scenario, A1 (as defined in Table A-2), that should be considered when this facility is utilized to support any case.

Table A-3. Applicable accidents and facilities.

Facility	Modulea	Accidents
Spent Fuel Receiving, Cask Handling and Fuel Unloading	A	A1
Examination and Characterization	B	A1
Naval Reactor Spent Fuel Examination and Characterization	C	A1, A5, A7, A8
Spent Fuel Repackaging	D	A1, A5,

		A7, A8
Canister Loading	E	A1, A7, A8
Interim Dry Storage	F	A1, A3
Interim Spent Fuel Storage Pool	G	A1, A5, A7, A8
F-Canyon/F-Area Separations	H, I	A1, A2, A3, A6
H-Canyon/H-Area Separations	J, K, L	A1, A2, A3, A6
Reactor Disassembly Basins	M	A1, A5, A7
Receiving Basin for Offsite Fuels	N	A1, A4, A5, A7, A8

a. As defined in WSRC (1994b).

A.2.5 Facilities and Reference Accidents Associated with each Alternative Case

Table A-4 links alternatives, specific cases, supporting facilities (modules), and accident scenarios. This table identifies the facilities that could be required to support each alternative by specific case. The combined associated accident scenarios for each facility provide the accident spectrum associated with the specific cases for each alternative.

A.2.6 Impacts from Radioactive Release Accidents

This section provides a quantitative discussion of potential consequences to the receptor groups identified in Section A.1.4.1. It also provides a qualitative discussion on potential health effects and consequences for workers at less than 100 meters (328 feet) for each of the potential accident scenarios.

Table A-4. Spent nuclear fuel facilities and accident spectrum by alternatives.

Alternative	Modules[a]	Accidents
1. NO ACTION		
Option 1 - Wet Storage	M, N	A1, A4, A5, A7, A8
2. DECENTRALIZATION		
Option 2a - Dry Storage	B, D, E, F, G, M, N	A1, A3, A4, A5, A7, A8
Option 2b - Wet Storage	B, D, E, G, M, N	A1, A4, A5, A7, A8
Option 2c - Processing	G, H, I, J, K, L, M, N	A1, A2, A3, A4, A5, A6, A7, A8
3. PLANNING BASIS		
Option 3a - Dry Storage	B, D, E, F, G, M, N	A1, A3, A4, A5, A7, A8
Option 3b - Wet Storage	B, D, E, G, M, N	A1, A4, A5, A7, A8
Option 3c - Processing	G, H, I, J, K, L, M, N	A1, A2, A3, A4, A5, A6, A7, A8
4. REGIONALIZATION		
Option 4a - Dry Storage	A, B, D, E, F, G, M, N	A1, A3, A4, A5, A7, A8
Option 4b - Wet Storage	A, B, D, E, G, M, N	A1, A4, A5, A7, A8
Option 4c - Processing	A, G, H, I, J, K, L, M, N	A1, A2, A3, A4, A5, A6, A7, A8
Option 4d - Dry Storage	A, B, C, D, E, F, G, M, N	A1, A3, A4, A5, A7, A8
Option 4e - Wet Storage	A, B, C, D, E, G, M, N	A1, A4, A5, A7, A8
Option 4f - Processing	A, C, G, H, I, J, K, L, M, N	A1, A2, A3, A4, A5, A6, A7, A8
Option 4g - Ship Out	M, N	A1, A4, A5, A7, A8
5. CENTRALIZATION		
Option 5a - Dry Storage	A, B, C, D, E, F, G, H, M, N	A1, A3, A4, A5, A7, A8
Option 5b - Wet Storage	A, B, C, D, E, G, M, N	A1, A4, A5, A7, A8
Option 5c - Processing	A, C, G, H, I, J, K, L, M, N	A1, A2, A3, A4, A5, A6, A7, A8
Option 5d - Ship Out	M, N	A1, A4, A5, A7, A8

a. Source: WSRC (1994b).

A.2.6.1 Radioactive Release Accidents and Consequences for Spent Nuclear Fuel

Alternatives. Table A-5 summarizes the information in Tables A-2 through A-4 and provides individual consequences (doses) based on accident type for each case. The table lists consequences for the four receptor groups as follows: Maximum Offsite Individual Dose, the Population to 80 kilometers (50 miles) Dose, the Worker Dose, and the Colocated Worker Dose.

Table A-5. Radioactive release accidents and consequences for spent nuclear fuel alternatives.

Description	Accident		Accident frequency (per year)	Maximally offsite individual dose (rem)	Population to 80 kilometers dose (person-rem)	Worker dose (rem)	Colocated worker dose (rem)
	1.	NO ACTION					
Option 1 Wet Storage	A1	Fuel Assembly Breach	1.6x10-1	2.0x10-3	1.7x101	(a)	1.2x10-2
	A4	Material Release (adjacent facility)	2.4x10-3	6.0x10-3	5.0x101	(a)	5.0x10-2
	A5	Criticality in Water	3.1x10-3	3.0x10-3	8.8x100	(a)	1.4x10-1
	A7	Spill/Liquid Discharge (external)	2.0x10-4	5.4x10-3	1.8x101	(a)	7.6x10-2
	A8	Spill/Liquid Discharge (internal)	1.1x10-1	2.4x10-10	2.0x10-6	(a)	2.0x10-11
	2.	DECENTRALIZATION					
Option 2a Dry Storage	A1	Fuel Assembly Breach	1.6x10-1	2.0x10-3	1.7x101	(a)	1.2x10-2
	A3	Material Release (dry vault)	1.4x10-3	2.1x10-6	6.9x10-3	(a)	(a)
	A4	Material Release (adjacent facility)	2.4x10-3	6.0x10-3	5.0x101	(a)	5.0x10-2
	A5	Criticality in Water	3.1x10-3	3.0x10-3	8.8x100	(a)	1.4x10-1
	A7	Spill/Liquid Discharge (external)	2.0x10-4	5.4x10-3	1.8x101	(a)	7.6x10-2
	A8	Spill/Liquid Discharge (internal)	1.1x10-1	2.4x10-10	2.0x10-6	(a)	2.0x10-11
Option 2b Wet Storage	A1	Fuel Assembly Breach	1.6x10-1	2.0x10-3	1.7x101	(a)	1.2x10-2
	A4	Material Release (adjacent facility)	2.4x10-3	6.0x10-3	5.0x101	(a)	5.0x10-2
	A5	Criticality	3.1x10-3	3.0x10-3	8.8x100	(a)	1.4x10-1

		in Water				
	A7	Spill/Liquid Discharge (external)	2.0x10-4	5.4x10-3	1.8x101	(a)	7.6x10-2
	A8	Spill/Liquid Discharge (internal)	1.1x10-1	2.4x10-10	2.0x10-6	(a)	2.0x10-11
Option 2c Processing	A1	Fuel Assembly Breach	1.6x10-1	2.0x10-3	1.7x101	(a)	1.2x10-2
	A2	Material Release (processing)	2.6x10-1	6.8x10-5	5.2x10-1	(a)	9.0x10-5
	A3	Material Release (dry vault)	1.4x10-3	2.1x10-6	6.9x10-3	(a)	(a)
	A4	Material Release (adjacent facility)	2.4x10-3	6.0x10-3	5.0x101	(a)	5.0x10-2
	A5	Criticality in Water	3.1x10-3	3.0x10-3	8.8x100	(a)	1.4x10-1
	A6	Criticality in Processing	1.4x10-4	7.0x10-3	8.6x100	(a)	2.6x10-1

Table A-5. (continued).

Description	Accident		Accident frequency (per year)	Maximally offsite individual dose (rem)	Population to 80 kilometers dose (person-rem)	Worker dose (person-rem)	Colocated worker dose (person-rem)
	2. DECENTRALIZATION						
	A7	Spill/Liquid Discharge (external)	2.0x10-4	5.4x10-3	1.8x101	(a)	7.6x10-2
	A8	Spill/Liquid Discharge (internal)	1.1x10-1	2.4x10-10	2.0x10-6	(a)	2.0x10-11
	3. PLANNING BASIS						
Option 3a Dry Storage	Same as Option 2a for Decentralization						
Option 3b Wet Storage	Same as Option 2b for Decentralization						
Option 3c Processing	Same as Option 2c for Decentralization						
	4. REGIONALIZATION						
Option 4a and 4d Dry Storage	Same as Option 2a for Decentralization						
Option 4b and 4e Wet Storage	Same as Option 2b for Decentralization						
Option 4c and 4f Processing	Same as Option 2c for Decentralization						
Option 4g Ship Out	Same as Alternative 1, No Action						
	5. CENTRALIZATION						
Option 5a Dry Storage	Same as Option 2a for Decentralization						
Option 5b Wet Storage	Same as Option 2b for Decentralization						
Option 5c Processing	Same as Option 2c for Decentralization						
Option 5d Ship Out	Same as Alternative 1, No Action						

a. The safety analysis reports from which information was extracted for these accidents were written before the issuance of DOE Orders 5480.23 (DOE 1992); previous orders did not require the inclusion of worker doses.

A.2.6.2 Impacts to Workers at Less than 100 Meters from Radiological

Releases. This section provides a qualitative discussion addressing the impacts due to potential radiological accident scenarios to workers at less than 100 meters (328 feet) involved in SRS spent nuclear fuel management. While worker fatalities may result from release initiators (i.e., plane crashes, seismic event, crane failure, etc.) and not as a direct consequence of a radiation release, this discussion considers only the radiological impacts of an accident, should it occur.

- A1. Fuel Assembly Breach - No fatalities to workers would be expected from radiological consequences because the release of the source term would be under water. Attenuation by the water would occur for most products, but the release of noble gases would cause a direct radiation exposure to workers in the area. However, because of the high metallic content of SRS spent nuclear fuel, only a very small fraction of the gases generated in an assembly would be released to the basin water. Air monitors in the area would warn personnel in the event of an airborne release. Timely evacuation would prevent substantial radiation exposures.

- A2. Material Release (Processing) - No fatalities to workers would be likely from radiological consequences (Meehan 1995). This scenario assumes that the material released from the process vessels would remain within the Canyon structure and be processed through the Canyon's ventilation and filtration system. Because of shielding effect from the thick concrete walls separating the vessels and areas occupied by workers, the exposures to workers are not expected to be significantly larger than those that would be received during routine operations.

- A3. Material Release (Dry Vault) - No fatalities to workers would be likely from radiological consequences. Medium energetic events resulting in the release of radioactive material from the Plutonium Storage Facility vault can result in the dispersal of radioactive materials. For these events, the radioactive material present would bypass the containment and disperse, but would result in a dose well below the lethal level. This assumes that a material release would be distributed into the volume of the smallest room for each unit of operation. It is further assumed that the operator is able to exit the room in 30 seconds (Du Pont 1989). This scenario presumes that the fractions of the plutonium volatized and transported are the same as those applied to the dispersal of the nonvolatile fission products of a criticality. Based on these assumptions, radiological exposure to the worker could occur.

- A4. Material Release (Adjacent Facility) - No fatalities to workers would be likely from radiological consequences. The rupture of a waste tank by an explosion could release airborne activity to the shielded cell if the accident occurred during one of the projected 150 times per year when regeneration of the portable columns took place (WSRC 1993a). Although some radiological exposure to the worker could occur, the risk to the worker from the initiating fire and explosion would predominate. Air monitors in the area would warn personnel in the event of an airborne release. Timely evacuation would prevent substantial radiation exposures.

- A5. Criticality in Water - No fatalities to workers would be likely from radiological consequences. The use of casks and the underwater handling of spent nuclear fuel greatly reduce the possibility of over-exposure of workers to radiation. The approximately 3 meters (10 feet) of water that covers all fuel provides an attenuation factor of 105 for intense gamma radiation and provides protection from direct radiation, even in the event of a criticality. However, a small chance of direct radiation exposure could result due to a floating fuel element or a fuel element inadvertently being raised too high. Strategically located radiation monitors reduce even this probability by alerting workers and sounding an evacuation alarm.

- A6. Criticality During Processing - The radiation field generated by a criticality incident could lead to fatalities among workers at the FB-Line facility. As discussed in Section A.2.2, FB-Line inadvertent criticality events are bounding for F- and H-Area spent fuel management processing facilities. This is assumed because workers involved in the FB-Line activities are in close proximity to plutonium metal. Of the 74 personnel that could be present during normal operations, 56 are expected to be within areas which the safety analysis report (WSRC 1993d) identifies as potential criticality accident locations. The shielding due to the concrete floors and walls, the distance between personnel, and the specific nature of the event reduce personnel dose so that only nearby personnel on the floor where the accident occurred would potentially receive a fatal dose. In the event of a criticality accident, DOE estimates that up to 4 deaths could occur, and as many as 50 other workers could receive non-fatal levels of direct radiation.

- A7. Spill/Liquid Discharge (External) - No fatalities to workers would be likely from radiological consequences because drainage of the water from the pool or basin would be expected to take several days, or under the most extreme circumstances, several hours, which provides sufficient time for workers to evacuate the area.

- A8. Spill/Liquid Discharge (Internal) - No fatalities to workers would be likely from radiological consequences. Minor releases of contaminated water have occurred at the Receiving Basin for Offsite Fuel hose rack platform during the handling of portable deionizers from the reactor areas. One such release was the result of an operator attempting to correct a small leak on a pressurized portable deionizer. The operator was subsequently sprayed with contaminated water, resulting in a radioactive exposure. A spill at the hose rack is not expected to release more than 378.5-liters (100 gallons) of contaminated water.

A.2.7 Point Estimates of Risk

Table A-6 lists the point estimate of risk for each reference accident considered for two receptors. The point estimate of risk is the product of frequency (in occurrences per year) and the number of potential latent fatal cancers. The number of potential latent fatal cancers is the product of dose (in rem for the individual or person-rem for the population) and the ICRP 60 risk factors (4.0 x 10-4 latent fatal cancer per rem for the worker or 5.0 x 10-4 latent fatal cancer per rem for the general public). These point estimates were used to determine the relative risk for each case and to determine the accident that becomes dominant if DOE retires specific facilities during the total period under consideration. For example, all alternatives begin with the immediate storage of spent nuclear fuel in wet pools; however, for the alternative considering interim dry storage, the accident dominating risk will change as the configuration of facilities utilized changes and as spent nuclear fuel or special nuclear material is placed in and remains in interim storage rather than being handled.

A.2.8 Fuel Transition Staging Risk

Table A-7 facilitates the examination of the dominant reference accident during the fuel handling, processing, and storage stages. The use of stages enabled a realistic comparison of risk over the evaluated period. For example, when all fuel has been unloaded, characterized, canned, and put into an interim storage position, consideration of fuel handling events is no longer meaningful.

A.2.9 Adjustment Factors for Comparison Between Alternatives

The accident scenarios described in this document (i.e., Appendix C) differ only slightly between the various alternatives. The scenarios do not account for variations in spent nuclear fuel shipments (including onsite operational transfers) and spent nuclear fuel storage inventories across the alternatives. To provide a realistic comparison across alternatives, DOE developed factors to adjust

Table A-6. Point Estimates of Risk for Reference Accident Scenarios.

Accident Scenario	Descriptions	Frequency (per year)	Potential Fatal Cancers[a]		Point Estimate of Risk[b]	
			Maximally	Population	Maximally	Population

			Exposed Individual	to 80 kilometers	Exposed Individual	to 80 kilometers
A1	Fuel Assembly Breach	1.6x10-1	1.0x10-6	8.5x10-3	1.6x10-7	1.4x10-3
A2	Material Release (processing)	2.6x10-1	3.4x10-8	2.6x10-4	8.8x10-9	6.8x10-5
A3	Material Release (dry vault)	1.4x10-3	1.1x10-9	3.5x10-6	1.5x10-12	4.9x10-9
A4	Material Release (adjacent facility)	2.4x10-3	3.0x10-6	2.5x10-2	7.2x10-9	6.0x10-5
A5	Criticality in Water	3.1x10-3	1.5x10-6	4.4x10-3	4.7x10-9	1.4x10-5
A6	Criticality in Processing	1.4x10-4	3.5x10-6	4.3x10-3	4.9x10-10	6.0x10-7
A7	Spill/Liquid Discharge (external)	2.0x10-4	2.7x10-6	9.0x10-3	5.4x10-10	1.8x10-6
A8	Spill/Liquid Discharge (internal)	1.1x10-1	1.2x10-13	1.0x10-9	1.3x10-14	1.1x10-10

a. ICRP 60 risk factor (5.0 x 10-4) latent fatal cancer per rem was used to determine potential latent fatal cancers.

b. Units for point estimates of risk are given in potential fatal cancers per year.

Table A-7. Dominant risks based on fuel transition stages.

Fuel/Material Stage	Maximally Exposed Individual Risk	Population to 80 Kilometers Risk
Wet storage	1.6x10-7 potential fatal cancer/yr based on accident scenario A1.	1.4x10-3 potential fatal cancer/yr based on accident scenario A1.
Dry storage	1.5x10-12 potential fatal cancers/yr based on accident scenario A3.	4.9x10-9 potential fatal cancers/yr based on accident scenario A3.
Processing (fuel "in-process" by DOE definition)	1.6x10-7 potential fatal cancer/yr based on accident scenario A1.	1.4x10-3 potential fatal cancer/yr based on accident scenario A1.

frequencies or consequences, depending on the specific circumstances of each alternative. This section describes the methodology and justification used to develop adjustment (scaling) factors for a relative comparison of adjusted point estimates of risk for each alternative on a case-by-case basis.

A.2.9.1 Classification of SRS Accident Scenarios for Applicability to

Adjustment Factors. This evaluation screened the SRS accident scenarios to determine which adjustment factor categories were applicable. Table A-8 lists the classification of the different SRS accident scenarios. These adjustment categories are as follows:

- Frequency sensitive due to spent nuclear fuel handling
- Frequency sensitive due to spent nuclear fuel inventories
- Consequence sensitive due to spent nuclear fuel inventories

Table A-8. Adjustment factor classification of SRS accidents.

Accident Scenarios	Accident Description	Frequency Sensitive (Handling)	Frequency Sensitive (Inventory)	Consequence Sensitive

(Inventory)

A1	Fuel Assembly Breach	X		
A2	Material Release (Processing)		X	
A3	Material Release (Dry Vault)			X
A4	Material Release (Adjacent Facility)	X		
A5	Criticality in Water	X		
A6	Criticality during Processing		X	
A7	Spill/Liquid Discharge (External)			X
A8	Spill/Liquid Discharge (Internal)			X

The following paragraphs provide the basis for each category selection:

- A1. Fuel Assembly Breach - The major initiator for this accident is the mishandling of a fuel assembly. For this reason, the accident frequency for this accident is adjusted to account for the annual number of fuel handling events. The amount of material involved in this accident is limited by the amount of damage that would occur due to the mishandling of a fuel assembly. Therefore, the bounding consequences of this accident are constant and independent of the amount of material available.

- A2. Material Release (Processing) - The probability that a release could occur during processing depends on the amount of material that would be processed. Therefore, the accident frequency for this accident is adjusted based on the spent nuclear fuel inventory. Because a maximum amount of material can be processed at any one time, the bounding consequences of this accident are independent of the amount of material on the site.

- A3. Material Release (Dry Vault) - The major contributor to the probability of occurrence for this release was external initiators that did not involve material handling. This supports using the same frequency for each alternative. The consequences of this accident are proportional to the amount of material available for release. Therefore, the bounding consequences for this accident are based on the amount of material to be stored.

- A4. Material Release (Adjacent Facility) - The initiator for this accident involves the discharge of coolant from a cask into a waste tank. The frequency of occurrence for this accident depends on the number of casks received; therefore, the frequency is adjusted to account for the annual number of fuel shipments.

- A5. Criticality in Water - The probability of occurrence of this accident was determined by considering the probability of occurrence of several initiating events. Many of these initiating events involved a criticality due to the mishandling of fuel. Therefore, the frequency for this accident is adjusted to account for the annual number of fuel handling events. The magnitude of the criticality accident is not a function of the amount of material available because the criticality is a highly unlikely, localized event. The consequences for this accident are not adjusted to account for the amount of material available.

- A6. Criticality During Processing - The probability that a criticality could occur during processing depends on the amount of material that will be processed. Therefore, the frequency for this accident is adjusted based on the spent nuclear fuel inventory. The magnitude of the criticality accident is not a function of the amount of material available because the criticality is a highly unlikely, localized event. The consequences for this accident are not adjusted to account for the amount of material available.

- A7. Spill/Liquid Discharge (External) - The major contributor to the probability of occurrence for this release was external initiators that did not involve material handling. This supports using the same frequency for each alternative. The consequences depend on the amount of fuel in the basin because an increase in the amount of fuel will increase the source term in the basin water. Therefore, the bounding consequences are adjusted for the amount of fuel to be stored.

- A8. Spill/Liquid Discharge (Internal) - The major contributor to the probability of occurrence for this release was external initiators that did not involve material handling. This supports using the same frequency for each alternative. The consequences depend on the amount of fuel in the basin because an increase in the amount of fuel will increase the source term in the basin water. For this reason the bounding consequences are adjusted for the amount of fuel to be stored.

A.2.9.2 Methodology for Determination of Onsite Shipping Frequencies.

This section discusses the methodology for determining the onsite shipping frequencies of spent nuclear fuel on a case-by-case basis for each alternative. The annual frequency of handling accidents will vary in direct proportion to the annual number of handling events. However, the consequences of the accident will not vary as a result of spent nuclear fuel handling activities because the amount of material involved in each handling event does not vary. This evaluation assumes that onsite shipments of spent nuclear fuel are near-term shipments, averaged over 5 years. Table A-9 provides a breakdown of current spent nuclear fuel inventories at SRS facilities.

Table A-9. Spent nuclear fuel inventories.

Facility	Number of Aluminum Assemblies[b]	Number of Aluminum Slugs (Buckets[c])	Number of Nonaluminum-Clad Assemblies	Number of Aluminum-Clad Assembly Shipments	Number of Aluminum-Clad Bucket Shipments	Number of Nonaluminum-Clad Assembly Shipments
Receiving Basin for Offsite Fuel (RBOF)	234	107 (2)	261	20	1	22
K-Reactor Basin	1,783	349 (7)	0	149	3	0
L-Reactor Basin	861	13,840 (256)	0	72	86	0
P-Reactor Basin	577	61 (2)	0	48	1	0
Totals	3,455	14,477 (268)	261	289	91	22

[a] Basis for inventory numbers: (WSRC 1994c).

[b] Assemblies include targets and fuel assemblies. Assembly shipments are based on 12 assemblies per shipment.

[c] Number of buckets calculated using 54 slugs per bucket. Bucket shipments are based on 3 buckets per shipment.

A.2.9.2.1 Alternative 1 - No Action - The SRS would send the

following number of shipments of aluminum-clad fuel sent to the Receiving Basin for Offsite Fuel from:

- K-Reactor Basin - 152;
- L-Reactor Basin - 158;
- P-Reactor Basin - 49;
- Total - 359 shipments.

All nonaluminum-clad fuel would be sent from the Receiving Basin for Offsite Fuel to a reactor basin (a total of 22 shipments).

The number of shipments would be 380. Because fuel handling would occur at both origin and destination, this number would double (i.e., 760 total shipments). Therefore, over 5 years, this alternative would have an average shipping rate of 152 shipments per year.

A.2.9.2.2 Alternative 2 - Decentralization

- Option 2a - Dry Storage - For this option, initial shipments would be the same as those for Alternative 1 (760 shipments at a rate of 152 per year). Subsequent shipments from all storage locations to the new dry storage facilities would total 402 shipments. Because fuel handling would occur at both origin and destination, this number would double (i.e., 804 total shipments). Because all fuel would be moved to dry storage within a 5-year period, this total would have an average rate of 161 shipments per year. Adding all shipments would produce a total of 1,564 shipments at a rate of 313 per year.
- Option 2b - Wet Storage - For this option, initial shipments would be the same as those for Alternative 1 (760 shipments at a rate of 152 per year). Subsequent shipments from all storage locations to the new wet storage facilities would total 402 shipments for existing SRS fuel. Because the receipt of offsite fuel would continue prior to the relocation of fuel to the new wet storage facilities, an additional 50 shipments would occur [assuming receipt of five shipments per year of offsite fuel (per Volume 1, Appendix I "Offsite Transportation of Spent Nuclear Fuel")] until 2005. The resulting fuel movement would total 452 shipments. Because fuel handling would occur at both origin and destination, this number would double (i.e., 904 total shipments). Therefore, over 5 years this option would have an average shipping rate of 181 shipments per year. Adding all shipments under this option would produce a total of 1,664 shipments at a rate of 333 per year.
- Option 2c - Processing - In this option, all aluminum-clad fuel would move from its present location to the process facilities. All nonaluminum-clad fuel would remain in its present storage locations. The result would be in a total of 380 shipments. As in the previous options, this number would double for a total of 760 shipments. Therefore, over 5 years this option would have an average shipping rate of 152 shipments per year.

A.2.9.2.3 Alternative 3 - Planning Basis

- Option 3a - Dry Storage - The movement of materials for this option would be identical to that for Option 2a, resulting in a total of 1,564 shipments at a rate of 313 per year.
- Option 3b - Wet Storage - The movement of materials for this option would be identical to that for Option 2b, with the exception of a delay in the receipt of foreign fuel until the new facilities are in operation. This would result in a total of 1,564 shipments at a rate of 313 per year.
- Option 3c - Processing - The movement of materials for this option would be identical to that for Option 2c, resulting in a total of 760 shipments at a rate of 152 shipments per year.

A.2.9.2.4 Alternative 4 - Regionalization

- Option 4a - Dry Storage - For this option, initial shipments would be the same as Alternative 1 (760 shipments at a rate of 152 per year). Subsequent shipments of the aluminum-clad fuel to the new dry storage facilities would total 380 shipments. (Note: Nonaluminum-clad fuel would be sent offsite from the reactor basins and would not contribute to any further onsite movements.). Because fuel handling would occur at both origin and destination, this number would double (i.e., 760 total shipments). Because all fuel would move to dry storage within about 5 years, this total would have an average shipping rate of 152 shipments per year. Adding all shipments would produce a total of 1,520 shipments at a rate of 304 per year.
- Option 4b - Wet Storage - The movement of materials for this option would be identical to that for Option 3b, with the exception of movement of the nonaluminum-clad fuel to the new wet storage facility. This fuel would move off the Site from the reactor basins and would not contribute to any further onsite movements. This would result in

a total of 1,520 shipments at a rate of 304 per year.

- Option 4c - Processing - The movement of materials for this option would be identical to that for Options 2c and 3c, resulting in a total of 760 shipments at a rate of 152 per year.
- Option 4d - Dry Storage - The movement of materials for this option would be identical to those for Options 2a and 3a, resulting in a total of 1,564 shipments at a rate of 313 per year.
- Option 4e - Wet Storage - The movement of materials for this option would be identical to that for Option 3b, resulting in a total of 1,564 shipments at a rate of 313 per year.
- Option 4f - Processing - The movement of materials for this option would be identical to those for Options 2c, 3c, and 4c, resulting in a total of 760 shipments at a rate of 152 per year.
- Option 4g - Ship Out - This option would require the shipping of all spent nuclear fuel at the SRS to a selected regional location. The movement of materials for this option would include the entire spent nuclear fuel inventory at the SRS, resulting in a total of 402 shipments at a rate of 81 per year.

A.2.9.2.5 Alternative 5 - Centralization

- Option 5a - Dry Storage - The movement of materials for this option would be identical to those for Options 2a and 3a, resulting in a total of 1,564 shipments at a rate of 313 per year.
- Option 5b - Wet Storage - The movement of materials for this option would be identical to that for Option 3b, resulting in a total of 1,564 shipments at a rate of 313 per year.
- Option 5c - Processing - The movement of materials for this option would be identical to those for Options 2c, 3c, and 4c, resulting in a total of 760 shipments at a rate of 152 shipments per year.
- Option 5d - Ship Out - This option would require the shipping of all spent nuclear fuel at the SRS to a selected central location. The movement of materials for this option would include the entire spent nuclear fuel inventory at the SRS, resulting in a total of 402 shipments at a rate of 81 per year.

A.2.9.3 Methodology for Determination of Offsite Shipping Frequencies.

This evaluation determined the total number of offsite shipments using the data contained in Volume 1, Appendix I, "Offsite Transportation of Spent Nuclear Fuel." The total number of Naval Fuel shipments was determined from Table 3 of "Methodology for Adjusting SNF Facility Accident Probabilities and Consequences For Different EIS Alternatives" (dated March 18, 1994).

Naval, foreign, and university shipments would occur throughout the interim management period and could be averaged over the 40-year period **covered by this EIS.** All other shipments would be averaged over 5 years.

A.2.9.4 Frequency Adjustment Factors for Fuel Handling. For this

analysis, DOE assumed the baseline fuel handling rate (events per year) to be the No Action alternative. For the other alternatives, this evaluation divided the expected spent nuclear fuel handling rate by the baseline spent nuclear fuel handling rate (No Action) to obtain the adjustment factor (see Table A-10).

A.2.9.5 Frequency/Consequence Adjustment Factors Due to Inventory. The

No Action alternative for the SRS would require the storage of 206 MTHM

(227 tons) of fuel. Using this amount as the baseline, this evaluation compared the amount of fuel for the other alternatives to the base number, as listed in Table A-11. These adjustment factors can be applied to either a frequency or a consequence, depending on the classification of the accident scenario as listed in Table A-8.

A.3 Chemical Hazard Evaluation

A.3.1 Selection of Reference Chemical Hazard

A review of the same safety analyses used to generate the spectrum of radiological accident scenarios failed to identify a quantitative discussion of chemical hazards. However, each of the safety analyses provided a qualitative discussion of chemical hazards. Thus, Section 5.15.3 discusses chemical hazards associated with existing spent nuclear fuel facilities qualitatively. This qualitative evaluation was determined to be appropriate based on three criteria: sliding scale in proportion to significance, public perception of severity, and long-term effects of chemicals not known. For completeness, a separate risk assessment (WSRC 1993c) provided a quantitative discussion of chemical hazards for the Receiving Basin for Offsite Fuel facility. This assessment described a bounding chemical hazard accident involving the release of nitrogen dioxide vapor.

Table A-10. Fuel handling frequency adjustment factors.

Option Number	Estimated Annual Shipping Rate	Frequency Adjustment Factor
Alternative 1 - No Action		
Option 1	152	Baseline
Alternative 2 - Decentralization		
Option 2a	316	2.08
Option 2b	333	2.19
Option 2c	157	1.03
Alternative 3 - Planning Basis		
Option 3a	375	2.47
Option 3b	375	2.47
Option 3c	216	1.42
Alternative 4 - Regionalization		
Option 4a	421	2.77
Option 4b	421	2.77
Option 4c	269	1.77
Option 4d	394	2.59
Option 4e	394	2.59
Option 4f	234	1.54
Option 4g	160	1.05
Alternative 5 - Centralization		
Option 5a	803	5.28
Option 5b	803	5.28
Option 5c	643	4.23
Option 5d	160	1.05

Table A-11. Inventory adjustment factors for each alternative.

Alternative	Inventory[a] (MTHM[b])	Adjustment Factor
No Action	206.27	Baseline
Decentralization	219.89	1.07
Planning Basis	222.76	1.08
Regionalization - A	213.09	1.03
Regionalization - B	256.62	1.24
Centralization	2,741.80	13.30

a. Source: Wichmann (1995).

b. Metric Tons Heavy Metal; to convert to tons, multiply by 1.1023.

A.3.2 Hazardous Chemical Inventories

The inventory of hazardous chemicals at each facility was determined by using the "Savannah River Site Tier Two Emergency and Hazardous Chemical Inventory Report" (WSRC 1994a) to get the facility's total chemical inventory, then listing those chemicals that also appeared on the EPA's "List of Lists"

(EPA 1990). The chemical inventories listed in Tables A-12 through A-15 represent facilities used for wet storage and/or processing of spent nuclear fuel. The SRS maintains no large-scale dry storage facilities; thus, chemical inventories for dry storage facilities are not listed.

Table A-12. Hazardous chemical inventory for the Receiving Basin for Offsite Fuel.

Chemical	Maximum Daily Amount (Kg)a	Average Daily Amount (Kg)
Ethylene glycol	2,981	23
Methyl ethyl ketone	2	2
Nitric acid	4,731	2,365
Phosphoric acid	3,953	3,953
Sodium hydroxide (caustic soda)	5,800	2,900
Sodium nitrite	3,070	1,535

a. To convert kilograms to pounds, multiply by 2.2046.

Table A-13. Hazardous chemical inventory for the reactor basins (typical).

Chemical	Maximum Daily Amount (Kg)a	Average Daily Amount (Kg)
Aluminum sulfate (solution)	570	230
Ethylene glycol (thermal arc torch coolant concentrate)	2	2
Hydrogen peroxide	1	1
Nitric acid	75	75
Sodium hydroxide	454	454
Sodium hypochlorite	11	6
Zinc	0.5	0.5

a . To convert kilograms to pounds, multiply by 2.2046.

Table A-14. Hazardous chemical inventory for H-Area.

Chemical	Maximum Daily Amount (Kg)a	Average Daily Amount (Kg)
Dichlorodifluoromethane (Freon 12)	227	68
Dichlorodifluoromethane (Racon 12)	227	0
Ethylene glycol	4.0	2.0
Hydrofluoric acid	1	0.5
Hydrogen peroxide	0.5	0.0
Mercury	4,900	4,900
Methyl ethyl ketone	3	3
Nitric acid	10	5
Nitric oxide	1,300	1,300
Phosphorus pentoxide	1	1
Potassium permanganate (Cairox)	200	100
Sodium hydroxide	1	1
Sodium hypochlorite	41	29
Sulfuric acid	1	0.5
Trichlorofluoromethane (Freon 11)	1,150	1,000
Trichlorofluoromethane (Genetron 11)	450	0

a . To convert kilograms to pounds, multiply by 2.2048.

Table A-15. Hazardous chemical inventory for F-Area.

Chemical	Maximum Daily Amount (Kg)a	Average Daily Amount (Kg)
Dichlorodifluoromethane (Freon 12)	1	0.5
Dichlorodifluoromethane (Racon 12)	1	0
Ethylene glycol	4	2
Hydrofluoric acid	1,177	1,177
Potassium permanganate	3	1
Sodium hydroxide	0.5	-
Sodium hypochlorite	7	4
Sulfuric acid	30	-
Trichlorofluoromethane (Freon 11)	900	450

a . To convert kilograms to pounds, multiply by 2.2048.

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APPENDIX D Naval Spent Nuclear Fuel Management Part A

Department of Energy
Programmatic Spent Nuclear
Fuel Management
and
Idaho National Engineering Laboratory
Environmental Restoration and
Waste Management Programs
Environmental Impact Statement
Volume 1
Appendix D
Naval Spent Nuclear Fuel Management
April 1995
U.S. Department of Energy
Office of Environmental Management
Idaho Operations Office

Appendix D
to Volume 1 of
Department of Energy
Programmatic Spent Nuclear Fuel Management
and
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Environmental Restoration and
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SUMMARY

INTRODUCTION

Volume 1 to the Department of Energy's Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Management Programs Environmental Impact Statement evaluates a range of alternatives for managing naval spent nuclear fuel expected to be removed from U.S. Navy nuclear-powered vessels and prototype reactors through the year 2035. The Environmental Impact Statement (EIS) considers a range of alternatives for examining and storing naval spent nuclear fuel, including alternatives that terminate examination and involve storage close to the refueling or defueling site. The EIS covers the potential environmental impacts of each alternative, as well as cost impacts and impacts to the Naval Nuclear Propulsion Program mission.

This Appendix covers aspects of the alternatives that involve managing naval spent nuclear fuel at four naval shipyards and the Naval Nuclear Propulsion Program Kesselring Site in West Milton, New York. This Appendix also covers the impacts of alternatives that involve examining naval spent nuclear fuel at the Expended Core Facility in Idaho and the potential impacts of constructing and operating an inspection facility at any of the Department of Energy (DOE) facilities considered in the EIS. This Appendix also considers the impacts of the alternative involving limited spent nuclear fuel examinations at Puget Sound Naval Shipyard. This Appendix does not address the impacts associated with storing naval spent nuclear fuel after it has been inspected and transferred to DOE facilities. These impacts are addressed in separate appendices for each DOE site.

BACKGROUND

The Naval Nuclear Propulsion Program is a joint U.S. Navy and DOE program responsible for all matters pertaining to naval nuclear propulsion. The Program is responsible for the nuclear propulsion plants aboard over 120 nuclear-powered warships powered by over 140 naval reactors and for nuclear propulsion work performed at six naval shipyards and two private shipyards. Removal of spent nuclear fuel from ships is ending at two of those shipyards as a result of recent decisions on base closures, and nuclear propulsion work at one of the private shipyards has not involved handling spent nuclear fuel for more than 15 years. The Program is also responsible for two government-owned, contractor-operated laboratories, two moored training ships, three land-based prototype reactors, and the Expended Core Facility located at the Naval Reactors Facility. The Naval Reactors Facility is located at the Idaho National Engineering Laboratory (INEL).

NAVAL SPENT NUCLEAR FUEL MANAGEMENT

Naval spent nuclear fuel is the fuel removed from naval nuclear propulsion plants. Naval fuel is designed to meet the demanding requirements needed to support long-term operation in a warship. To meet these requirements, it is designed to withstand battle shock and to retain its radioactivity so as to minimize radiation dose to the ships' operating personnel who must live and work in close proximity to the reactor. Even after decades of service, the spent nuclear fuel retains its strength and high integrity.

For nearly 40 years, naval spent nuclear fuel has been shipped by rail in shielded shipping containers from naval shipyards and prototypes to the Expended Core Facility in Idaho where it is removed from the shipping containers and placed into water pools at the Expended Core Facility. All fuel is examined for specific characteristics and for abnormalities. Selected fuel is given more detailed examination. Naval fuel examinations provide assurance that operations of shipboard reactors can continue without restriction. These examinations have significantly contributed to the longer core lives and continued safe performance of current naval reactor designs. This work has also resulted in substantial reduction in the amount of spent nuclear fuel generated by the Naval Nuclear Propulsion Program.

DESCRIPTION OF ALTERNATIVES

The EIS considers five general alternatives for spent nuclear fuel management. The general alternatives are described in Chapter 3 of Volume 1. Naval spent nuclear fuel would be managed under each of these general alternatives as follows.

No Action

Naval reactors would be refueled and defueled as planned. Naval spent nuclear fuel would be stored in transport casks at the Navy or DOE facility where defueling was conducted. (Fuel generated from ships at Newport News Shipbuilding would be transferred to Norfolk Naval Shipyard.) No further spent nuclear fuel examination would be conducted. This alternative would require a phase-in period while additional containers are procured for spent nuclear fuel storage. During an approximately 3-year period, spent nuclear fuel would be transported in shipping containers to the Expended Core Facility in Idaho. The containers would be unloaded and used to support additional refuelings and defuelings.

Decentralization

For naval spent nuclear fuel, three options are considered. Each option would require a phase-in period while facilities are developed. The length of the phase-in period would depend on the option and mode of storage selected. During the phase-in period, spent nuclear fuel would be transported in shipping containers to the Expended Core Facility in Idaho. The containers would be unloaded and used to support additional refuelings and defuelings.

a. Store naval spent nuclear fuel at the Navy or DOE facility where defueling is conducted. (Fuel generated from ships at Newport News Shipbuilding would be transferred to Norfolk Naval Shipyard.) At each storage location, dry storage in shipping containers and dry casks as well as wet storage in a water pool facility are considered.

b. Modify the existing water pool facility at Puget Sound Naval Shipyard to conduct the maximum practical amount of naval spent nuclear fuel examinations at that site. Store naval spent nuclear fuel at the Navy or DOE facility where defueling is conducted. (Fuel generated from ships at Newport News Shipbuilding would be transferred to Norfolk Naval Shipyard.) At each storage location, dry storage in shipping containers and dry casks as well as wet storage in a water pool facility are considered.

c. Ship naval spent nuclear fuel to the Expended Core Facility for examination, then return the fuel after examination to the Navy or DOE facility where defueling is conducted. (Fuel generated from ships at Newport News Shipbuilding would be transferred to Norfolk Naval Shipyard.) At each storage location, dry storage in shipping containers and dry casks as well as wet storage in a water pool facility are considered.

1992/1993 Planning Basis

The historic practice of transporting all spent nuclear fuel removed from naval reactors to the Expended Core Facility in Idaho for examination would resume. Following examination, fuel would be transferred to DOE for management at the Idaho Chemical Processing Plant pending final disposition.

Regionalization

The overall Regionalization alternative includes two options. The first option involves managing spent nuclear fuel at three DOE sites (Hanford Site, the INEL, and the Savannah River Site) based on fuel type. Under this option, the historical practice of transporting spent nuclear fuel removed from naval reactors to the Expended Core Facility in Idaho for examination would resume. Following examination, fuel would be transferred to DOE for management at the Idaho Chemical Processing Plant pending final disposition.

The second overall option involves managing spent nuclear fuel at a Western Regional Site and an Eastern Regional Site, based primarily on the originating location of the fuel. Under this option, naval fuel would be allocated to one site, either the western or the eastern site, for examination and storage. This Appendix evaluates the potential impacts of examining naval spent nuclear fuel at all of the potential sites.

Centralization

The Centralization alternative would collect all of the DOE's current and future spent nuclear fuel at one DOE site. The Hanford Site, the INEL, the Nevada Test Site, the Oak Ridge Reservation, and the Savannah River Site have been considered as candidates for this single site. If the INEL were selected, then naval spent nuclear fuel would be examined at the Expended Core Facility and would be stored at the Idaho Chemical Processing Plant. If a site other than INEL were selected, then the Expended Core Facility would be shut down and a new or modified facility for examination and additional storage facilities would be constructed at the selected site.

SITES CONSIDERED FOR NAVAL SPENT NUCLEAR FUEL MANAGEMENT

Naval Shipyards and Prototypes - The EIS evaluates four naval shipyards, Puget Sound Naval Shipyard at Bremerton, Washington; Norfolk Naval Shipyard at Portsmouth, Virginia; Portsmouth Naval Shipyard at Kittery, Maine; and Pearl Harbor Naval Shipyard at Pearl Harbor, Hawaii, for management of naval spent nuclear fuel only. The EIS also evaluates the Kenneth A. Kesselring Prototype Site at West Milton, New York. The four shipyard locations are industrial in nature and located near harbor areas. The Kesselring Site is a 3900-acre facility located in the mid-eastern sector of New York State in a wooded rural environment.

Idaho National Engineering Laboratory - This is the location of the Naval Reactors Facility which is also the present location of the Expended Core Facility. It is located in southeastern Idaho and occupies about 890 square miles of desert. The Idaho National Engineering Laboratory is presently used for industrial and support operations associated with energy research and waste management activities, grazing, recreational uses, and environmental research. It is remote from urban areas and occupies a controlled federal reservation which is largely undisturbed from its natural state.

Savannah River Site - The Savannah River Site in South Carolina is the location of one of the Department of Energy's weapons production sites. The P, K, and L Reactors at this location produced plutonium and tritium in support of the nation's nuclear weapons program. The Savannah River Site is located in the eastern United States and is in a heavily wooded environment which is returning to a more natural state from its previous agricultural uses. It is 310 square miles in area.

Hanford Site - The Hanford Site in the State of Washington is the location of one of the Department of Energy's weapons production sites. The N-Reactor at this site was used by the DOE through the years for the production of plutonium in support of the nation's nuclear weapons program. The Hanford Site is in the western United States on open, vacant desert land. It is 560 square miles in area which is largely undisturbed from its original state.

Oak Ridge Reservation - The Oak Ridge Reservation in Tennessee is the location of one of the Department of Energy's facilities which was primarily used to support the nation's nuclear weapons program. The Y-12 Plant at this location was used for processing highly enriched uranium for fuel elements used in the Savannah River reactors. The Oak Ridge Reservation is located in the eastern United States and is in a heavily wooded environment. It is 55 square miles in area, and consists of three industrialized areas separated by undeveloped forest land.

Nevada Test Site - The Nevada Test Site in Nevada has been a location for performing nuclear weapons testing. This site has been used by the DOE for activities in support of the national nuclear weapons program. The Nevada Test Site is in the western United States and is located in open, vacant desert land. It is 1350 square miles in area.

ANALYSES

This EIS evaluates the potential environmental impact of each alternative, including both the construction of new facilities and management operations at those facilities (transport, receipt, handling, examination, and storage of naval spent nuclear fuel). In general, accident analyses focus on accidents which have the probability to occur at least once every 10 million years. The range of accidents considered includes those resulting from human errors or mechanical failure such as airplane crashes into storage facilities and improper spent nuclear fuel handling, as well as natural disasters such as earthquakes and tornadoes. Both radiological and non-radiological impacts were considered.

The cumulative impacts of spent nuclear fuel management and other operations at these facilities have also been evaluated.

RESULTS AND COMPARISON OF ALTERNATIVES

Implementation of some of the alternatives would require construction or modification of facilities for storage of naval spent nuclear fuel at naval sites or a replacement for the Expended Core Facility at a DOE site. The locations for any new facilities would be selected from space already available on existing federally owned property, so no additional land would be withdrawn from public use at any site. The only exception to this might occur if the Barnwell Nuclear Fuel Plant at Savannah River were to be purchased and removed from the public domain. New facility locations would be chosen to avoid impacts on the cultural, archaeological, aesthetic, or scenic values of the area and to ensure that the rights or interests of Native American or Native Hawaiian groups would not be infringed. No site listed in the National Register of Historic Places would be affected. Ecologically sensitive areas, such as those in the vicinity of any threatened or endangered species, would be avoided. Construction activities associated with any naval spent nuclear fuel storage or examination facility would comply with all applicable laws and regulations, using established procedures for preserving air and water quality and previously unknown archaeological or cultural artifacts encountered and for minimizing such impacts as noise and disturbance or destruction of habitat.

No new naval spent nuclear fuel storage or examination facility would release water carrying radioactive or hazardous material to the environment. In 40 years of receipt, transportation, handling, and examination of naval spent nuclear fuel, the Naval Nuclear Propulsion Program has never had a release of radioactivity that has had a significant effect on the environment. Based on the operations that would be performed and the controls that would be in place, the impacts on air, water, ecological, or geological resources of any naval facility considered would be negligible. Furthermore, experience has shown that since naval spent nuclear fuel management is a low-intensity industrial activity, its contributions to noise and traffic would be inconsequential and its utility needs would generally be within the capabilities of the candidate sites. The Hanford Site and Nevada Test Site are possible exceptions to this because they are already operating at or near their electrical utility capacities and may require additional capacity to accommodate a new Expended Core Facility.

In the unlikely event of any accident involving naval spent nuclear fuel, it is estimated that no more than 210 acres of land would be affected for the most severe case, and in the other accidents analyzed, smaller areas of land would be affected. The affected area would require decontamination and during this cleanup, access controls would have to be established. However, due to the limited land area affected, it is judged that these restrictions would only be temporary and the impact on issues such as economics, treaty rights, tribal resources, ecology, and land use would be small and limited in time. The remediation actions would be simpler in rural areas than in urban areas, but, provided that prudent controls and remediation operations were promptly implemented, the affected land and buildings could be recovered in either case. As demonstrated in the accident analyses in this appendix, the human health effects would not be large and the effects on wildlife and other biota would also not be large, partly due to the relatively small area affected and partly because of the limited effects of the accident.

The radiological and non-radiological impacts of all the alternatives considered would be small. After consideration of the full range of environmental impacts and other effects associated with the management of naval spent nuclear fuel, it is judged that for all of the alternatives considered, the impacts on the ecology, cultural and aesthetic values, air and water resources, geology, and such areas as noise, traffic, and utilities, normally associated with most daily activities, would be so small and differ so little among alternatives for naval spent nuclear fuel that they would be of little assistance in differentiating among the alternatives.

The areas of impact which are of special interest to the public or which provide the most distinct contrasts among the alternatives are public health, socioeconomics, cost, and the Naval Nuclear Propulsion Program mission.

Public Health Impacts

A primary concern for most people is the risk to the public from exposure to radiation or radioactive material for each of the alternatives. The exposure could be a result of normal operations or an accident. A practical method often used to characterize the public risk resulting from federal actions such as these is to estimate the number of prompt fatalities or cancer fatalities that might result.

The analyses in this EIS show that there would be no prompt fatalities from the radiation exposure associated with accidents (or normal operations) for any of the alternatives considered and that there would be no latent cancer fatalities under any of the alternatives. However, for the No Action and Decentralization alternatives, under which naval spent nuclear fuel would be stored at a naval shipyard, the risks to a member of the public would be higher than for other alternatives.

Figure S-1 provides an overall comparison of the alternatives in terms of the calculated increase in the number of cancer fatalities that might occur in the general population over 40 years of operation for each alternative. It is important to emphasize that these cancer fatalities are calculated results rather than actual expected fatalities. This is because the expected number of such fatalities during normal operations is so small as to be indistinguishable relative to the larger number of such deaths expected from naturally occurring conditions and other man-made effects not related to naval spent nuclear fuel operations. This is not meant to trivialize the importance of radiation-induced cancer fatalities but, rather, is meant to put the issue in perspective. In all the alternatives, thousands of years of facility operation and transportation of naval spent nuclear fuel would be required before a single additional fatal cancer might be expected to occur. To provide some perspective, the naturally occurring radioactive materials in fertilizer used to produce food crops contribute about 1 to 2 millirem per year to an average American's exposure to radiation. Using the same calculational method used to determine the cancer fatality risk for the Naval Nuclear Propulsion Program alternatives, the exposures from consuming food grown with fertilizer result in 125 to 250 cancer fatalities annually in the United States.

Figure S-1. Risk from normal operations by alternative (fatal cancers to the general population over 40 years from facility operations and transportation).

The most severe risks for a facility accident were determined to be from an airplane crash into a dry storage container at the Pearl Harbor Naval Shipyard. This accident was calculated to result in 26 cancer fatalities and had a probability of occurring about once every 100,000 years. This accident has been calculated to produce a risk of less than 0.0003 additional cancer fatalities per year. The risks from all other accidents associated with examination or storage of naval spent nuclear fuel were much less than this. In general, the risks from facility accidents tended to be worse for the No Action and Decentralization alternatives, because for these alternatives fuel would be stored at sites which are located close to large population centers. For transportation accidents, the potential risks varied with the distances to be traveled, being least for the No Action and the Decentralization - No Examination alternatives which would involve transportation over short distances to storage locations near where the fuel is removed from reactors.

Socioeconomic and Cost Impacts

The socioeconomic impacts of implementing each of the alternatives would differ somewhat and are summarized in Table S-1. The primary socioeconomic impact of the alternatives considered would be on employment. Nation-wide employment levels would not vary significantly among alternatives for managing naval spent nuclear fuel and therefore do not provide a basis to distinguish among the alternatives. The maximum impact on local employment levels would be caused by alternatives requiring development of new naval spent nuclear fuel examination capability at a DOE facility other than INEL while terminating these activities at INEL. Continuing current practices of transporting naval spent nuclear fuel to the Expended Core Facility at INEL for examination followed by transfer to the DOE for storage would result in the minimum disruption of employment levels.

As shown in Figure S-2, there are large differences in the costs associated with all alternatives. These costs include the costs that would be incurred from construction of new facilities and containers, naval spent nuclear fuel transportation, and facility operation. In general, lower costs are associated with those alternatives that support examination of naval spent nuclear fuel with existing facilities and those alternatives that terminate or severely curtail spent nuclear fuel examination. The higher costs are associated with those alternatives that require construction of a new Expended Core Facility and those alternatives that use shipping containers for storage.

Table S-1. Summary of potential socioeconomic impacts.

Alternative	Long-term Impacts at INEL	Long-term Impacts at Other Sites
1. No Action	Lose 500 jobs	Add 50-100 jobs at naval sites
2. Decentralization		
- No Examination	Lose 500 jobs	Add 50-200 jobs at naval sites
- Limited Examination	Lose 500 jobs	Add 110-260 jobs at naval sites
- Full Examination	No change	Add 50-200 jobs at naval sites
3. 1992/1993 Planning Basis	No change	No change
4/5. Regionalization or Centralization		

- Idaho National Engineering Laboratory	No change	No change
- Hanford Site	Lose 500 jobs	Add 500 permanent jobs and some construction jobs at Hanford
- Savannah River Site	Lose 500 jobs	Add 500 permanent jobs and some construction jobs at Savannah River
- Nevada Test Site	Lose 500 jobs	Add 500 permanent jobs and some construction jobs at NTS
- Oak Ridge Reservation	Lose 500 jobs	Add 500 permanent jobs and some construction jobs at ORR

Figure S-2. Summary of costs by alternative (facility and transportation costs over 40 years).

Mission Impacts

Two important components of Naval Nuclear Propulsion Program operations are the safe management of naval spent nuclear fuel and support of the Navy's fleet of nuclear-powered warships.

Based on the analyses in this EIS, all alternatives considered would allow safe storage of naval spent nuclear fuel until a permanent repository becomes available. However, some of the alternatives would not provide equal levels of Fleet support. Alternatives which limit or terminate naval spent nuclear fuel examination would severely impact ongoing research and development work. Naval spent nuclear fuel examination results are used to confirm the adequacy of design features, explore material performance, and confirm or adjust computer predictions of fuel performance. This information contributes to the design and manufacturing of new naval reactor cores as well as the safe operation of nuclear-powered warships. Of the alternatives allowing full examination at the INEL, Hanford Site, Savannah River Site, Oak Ridge Reservation, or Nevada Test Site, examination at the INEL would have the smallest mission impact due to the presence of existing facilities and equipment for performing this work, and the presence of a highly skilled work force, all of which would need to be relocated or reassembled if a new examination site were selected.

CONCLUSION - PREFERRED ALTERNATIVE

The Navy's preferred alternative for the management of naval spent nuclear fuel would continue the historic, technically sound and safe practice of conducting refueling and defueling of nuclear-powered warships and prototypes as planned, transporting naval spent nuclear fuel to the Expended Core Facility at INEL for full inspection and examination, and transferring naval spent nuclear fuel to the DOE facility for storage pending availability of a method for permanent disposition. This preferred alternative is based on consideration of environmental, socioeconomic, cost, and mission impacts of each alternative.

The analyses contained in this EIS demonstrate that the environmental impacts of implementing any of the alternatives would be very small for normal operations and accident conditions. The analysis results do not provide a basis to distinguish among the alternatives in most of these areas. The socioeconomic impacts of the alternatives also do not provide a basis to distinguish among the alternatives.

The Navy's preferred alternative is, therefore, based on impacts to the Navy's mission and on cost. Alternatives that limit or terminate naval spent nuclear fuel examination would adversely affect Fleet support and the development of new naval reactors. Primarily because of the existing infrastructure, examination followed by storage at INEL would best support the Naval Nuclear Propulsion Program mission and would be the least cost alternative allowing for full examination of naval spent nuclear fuel.

The alternatives which involve the Navy's preferred alternative are: 1992/1993 Planning Basis alternative and the Regionalization and Centralization alternatives that include the use of the Expended Core Facility at INEL.

1. INTRODUCTION

This appendix describes the alternatives which have been evaluated for the examination and storage of spent nuclear fuel from U. S. naval nuclear shipboard and prototype reactors. The spent fuel is removed during reactor refuelings and defuelings at naval and commercial shipyards and at the prototype sites. The alternatives include a range of options for managing naval spent fuel through the year 2035. The options for spent fuel examination include ceasing all examinations, examining a limited amount of fuel at a naval shipyard, and performing a full range of examinations at the current facility (Idaho National Engineering Laboratory) or at another Department of Energy (DOE) facility. The options for naval spent fuel storage include storage at the refueling and defueling sites (in some cases, it is necessary to move the fuel to the closest acceptable Navy shipyard), storage at the current facility, or storage at another DOE facility. Spent fuel transportation aspects will depend on the examination and storage alternatives selected.

Naval spent fuel examination, whether at a naval or DOE site, will remain the responsibility of the Naval Nuclear Propulsion Program. This appendix therefore addresses the environmental impacts of naval spent fuel examination. This appendix also addresses the environmental impacts of long-term storage of spent fuel at naval shipyards and prototype sites. The environmental impacts of long-term spent fuel storage at DOE facilities are addressed in the Environmental Impact Statement appendices applicable to those sites.

2. BACKGROUND

2.1 NAVAL NUCLEAR PROPULSION PROGRAM OVERVIEW

The Naval Nuclear Propulsion Program is a joint Navy/Department of Energy (DOE) organization responsible for all matters pertaining to naval nuclear propulsion pursuant to Presidential Executive Order 12344, enacted as permanent law by Public Law 98-525 (42 USC 7158). The Program is responsible for:

a. The nuclear propulsion plants aboard over 120 warships powered by over 140 naval reactors.
b. Moored Training Ships located in Charleston, South Carolina used for naval nuclear propulsion plant operator training.
c. Nuclear propulsion work performed at eight shipyards (six public and two private).
d. Two DOE government-owned, contractor-operated laboratories devoted solely to naval nuclear propulsion research, development, and design work.
e. Three land-based prototype naval reactors used for research and development work and training of naval nuclear propulsion plant operators.
f. The Expended Core Facility, located at the Naval Reactors Facility which is a part of the Idaho National Engineering Laboratory.

More detailed discussion is available in the references listed in Section 2.6 (DOE/DOD 1994; Duncan 1990; Hewlett and Duncan 1974).

2.2 HISTORY AND MISSION OF THE PROGRAM

In 1946, at the conclusion of World War II, Congress passed the Atomic Energy Act, which established the Atomic Energy Commission (AEC) to succeed the wartime Manhattan Project, and gave it the sole responsibility for developing atomic energy. At that time, Captain Hyman G. Rickover was assigned to the Navy Bureau of Ships, the organization responsible for naval ship design. Captain Rickover recognized the military implications of successfully harnessing atomic power for submarine propulsion, and that it would be necessary for the Navy to work with the AEC to develop such a program. By 1949, Captain Rickover had forged an arrangement between the AEC and the Navy that led to the formation of the Naval Nuclear Propulsion Program. In 1954, the nuclear submarine USS NAUTILUS put to sea and demonstrated the basis for all subsequent U.S. nuclear-powered warship propulsion designs. In the 1970's, government restructuring moved the AEC part of the Naval Nuclear Propulsion Program from the AEC (which was disestablished) to what became the Department of Energy. Although the Naval Nuclear Propulsion Program grew in size and scope over the years, it retained its dual responsibilities within the Department of Energy and the Department of the Navy, and its basic organization, responsibilities, and technical discipline have remained much as when it was first established.

By eliminating altogether the need for oxygen for propulsion, nuclear power offered a way to drive a submerged submarine without the need to resurface frequently. In addition, nuclear power offered a way to drive a submerged submarine at high speed without concern for fuel consumption.

Nuclear propulsion, though originally developed for submarines, significantly enhances the military capability of surface ships. Nuclear propulsion provides virtually unlimited high-speed endurance without dependence on tankers and their escorts. Moreover, the space normally required for propulsion fuel in oil-fired ships can be used for weapons and aircraft fuel in nuclear-powered ships.

Naval fuel is designed to meet the very stringent operational requirements for naval nuclear propulsion reactors. Because of its military design, it will maintain its integrity indefinitely under the far less demanding conditions encountered during land-based storage. Naval fuel is designed to operate in a high-temperature and high-pressure environment for many years. Current designs are capable of over 20 years of successful operation. Measurements of the corrosion rates for current naval fuel designs have shown that naval spent nuclear fuel could be safely stored for periods far, far longer than the 40 years considered in this Environmental Impact Statement (EIS) in the cool water or air used for storage. Naval fuel uses highly corrosion-resistant materials for fuel and cladding which can withstand high-intensity radiation and harsh environments. As a result, the fuel is very strong and has very high integrity. The fuel is designed, built, and tested to ensure that the fuel construction will contain and hold the radioactive fission products. Naval fuel totally contains fission products within the fuel - there is no fission product release from the fuel in normal operation. Since the nuclear reactor core contains a large quantity of fission products, it is essential to contain them within the nuclear fuel in order to minimize radiation exposure to a ship's crew. Naval fuel is extremely rugged. It can withstand combat shock loads which are well in excess of 10 times the seismic loads for which commercial nuclear power plant fuel is designed. It routinely operates with rapid changes in power level since naval ships must be able to change speed quickly in operational situations. Naval fuel consists of solid components which are non-explosive, non-flammable, and non-corrosive. The ruggedness of naval fuel is demonstrated by the fact that two nuclear-powered ships were lost at sea in the 1960's, and subsequent environmental monitoring shows no release of fission products from the fuel despite the catastrophic nature of the loss of the ships (NNPP 1994a). Also, naval spent nuclear fuel examined after 28 years of storage in a water pool exhibited no detectable deterioration. Although spent nuclear fuel is highly radioactive, it is not regarded as "waste"; it requires special handling procedures, shielding, and other measures to isolate it from people and the environment.

The integrity of naval nuclear fuel is due in part to a long-standing program of examination of spent fuel after it has been removed from prototype reactor plants and operating ships. These examinations have been conducted at the Idaho National Engineering Laboratory (INEL) since the beginning of the Naval Nuclear Propulsion Program. Construction and early operation of the original INEL Expended Core Facility (ECF) occurred between 1957 and 1962. The original building contained a water pool and nine shielded cells connected to the water pool by a transfer tunnel. As examination requirements changed, the ECF underwent several expansion programs.

The first and second expansions, in 1962 and 1963, were prompted by the initiation of irradiated test specimen examinations at ECF. In the 1970's, the third expansion occurred with the addition of new, larger hot cells. The fourth expansion (1979-1987) included the extension of the ECF building and water pools for the addition of the Breeding Nondestructive Assay Facility. This addition was for the receipt and examination of the Light Water Breeder Reactor nuclear fuel following its operation in the former PWR Shippingport Atomic Power Station. The work at ECF has continued at or near capacity, receiving, handling, and examining spent fuel from naval reactor plants.

The examinations of naval spent nuclear fuel are essential to meeting the goals of the Naval Nuclear Propulsion Program. The primary goals that are supported by examinations are:

- Continued safety of naval reactors
- The design of new reactors having extended lifetimes
- Improvements in nuclear fuel performance
- Demonstration of satisfactory operation of existing naval reactors by providing confirmation of their proper design and allowing maximum depletion of their fuel
- Validation of design models for new core types.

The goal of the extended lifetime reactor design is to have the reactor core last for the life of the ship. Such a design would eliminate the need to refuel the reactor during its useful lifetime. It would also reduce the cost of fueling the ship, and would increase the time that such a ship would be in active service rather than being refueled.

This EIS assumes that the extended-lifetime goal is partially achieved. Based on current technology, the EIS assumes that each of the three SEAWOLF submarines will need to be refueled once during the period to the year 2035. Based on anticipated developments supported by new data from the examinations of naval spent nuclear fuel, this EIS also assumes that each of the New Attack Submarine Class will not need to be refueled during the period to 2035.

If the examinations of naval spent nuclear fuel are terminated and the goal of a life-of-the-ship core is not achieved, more naval spent nuclear fuel will be created than is otherwise anticipated. The number of shipments of naval spent nuclear fuel during the period from 1995 to 2035 would increase from about 580 to about 630 and the corresponding amount of naval spent nuclear fuel would increase from 65 metric tons of heavy metal (MTHM) to about 70 metric tons of heavy metal.

Similarly, the goals for safety, improved fuel performance, and satisfactory operation of naval reactors will depend on continuing the examinations of naval spent nuclear fuel.

2.3 REGULATORY FRAMEWORK

The Naval Nuclear Propulsion Program includes activities conducted by both the U.S. Navy and the Department of Energy. Executive Order 12344, enacted as permanent law by Public Law 98-525, and the Atomic Energy Act of 1954 establish the responsibility and authority of the Director of the Naval Nuclear Propulsion Program (who is also the Deputy Assistant Secretary for Naval Reactors within the Department of Energy) for all facilities and activities that comprise the Program. These executive and legislative actions establish that the Director is responsible for all matters pertaining to naval nuclear propulsion, including direction and oversight of environmental, safety, and health matters for all program facilities and activities.

The federal permits, licenses, and other entitlements listed below may need to be obtained to implement the alternative selected. Existing federal permits, licenses, and entitlements will be modified as required. Applicable state and local permits, licenses, and entitlements will be obtained or modified, as necessary.

- National Pollutant Discharge Elimination System (NPDES) Permit as required by the Federal Water Pollution Control Act (FWPCA), 33 U.S.C. - 1251 et seq.
- NPDES General Permit for Stormwater Discharges from Construction Sites as required by the FWPCA, 33 U.S.C. - 1251 et seq.
- Permit to emit hazardous air pollutants (radionuclides) under the Clean Air Act (CAA), 42 U.S.C. - 7401 et seq., as amended by the Clean Air Act Amendments of 1990.
- Department of Energy Certificate of Compliance for Radioactive Materials Packages in accordance with the Atomic Energy Act (AEA), 42 U.S.C. - 2011 et. seq.

2.4 NAVAL SPENT NUCLEAR FUEL

2.4.1 Summary of Naval Spent Nuclear Fuel Operations

For approximately 40 years, naval spent nuclear fuel has been shipped by rail to the Naval Reactors Facility at the INEL, where it is removed from the shielded shipping containers and placed into the water pools at the ECF. All spent fuel received at the ECF is visually examined externally for evidence of any unusual condition such as unexpected corrosion, unexpected wear, or structural defects. After the fuel assembly structural components have been removed, the interior of the assembly is examined for the conditions discussed above. In addition, the assembly is examined for distortions from irradiation, heat, or the fission process which could interfere with the even distribution of primary coolant and consequent heat removal. The inspection also checks for possible flow obstructions due to foreign material or excessive corrosion product buildup. About 10 to 20 percent of the spent naval reactor cores are given more detailed examinations for such purposes as confirming the adequacy of new design features, exploring materials performance concerns, and obtaining detailed information to confirm or adjust computer predictions of neutron physics, heat transfer, or hydraulic flow and distortion. These detailed examinations may include metallography to determine corrosion film thicknesses, dimensional measurements to determine fuel assembly distortion, and radiochemical analysis to determine core depletions, as well as other inspections. As discussed below, the examination program is essential in supporting the Navy's continued safe operation of naval reactors and design of new, improved fuel having a longer lifetime.

Examination of all spent naval fuel is essential to the mission of the Navy for three reasons: to provide data on current reactor performance, to validate models used to predict future performance, and to support research to improve reactor design.

Naval fuel examinations provide real data on reactor cores installed in ships currently operating in the fleet. This information is essential to validate calculational models and analyses. Through the years, the Naval Nuclear Propulsion Program has built a substantial technical database from examinations of earlier reactor core types. The Program predicts the performance of current core types with calculational models supported by this database. Essentially no information exists yet on core types that will form the backbone of the nuclear fleet for the foreseeable future (Trident class submarines, LOS ANGELES class submarines, and NIMITZ class aircraft carriers). Data from these reactor core types are necessary to validate basic assumptions of current models, provide a measure of variability which exists between individual cores and within a single core, and identify any unanticipated effects of operation that have not been evaluated or accounted for in current models.

Confidence in the validity of engineering models is essential for assurance that ship operations can continue without restriction. Since reactors operating in the fleet are not taxed to the limits of their design during peacetime operations, the Program requires a technically sound basis for continuing to conclude that we have a robust design. Prototype reactors cannot by themselves provide this information, as their operation is not identical to that of a warship. The fact that a core operated satisfactorily with no indication of a problem during a normal shipboard lifetime does not guarantee that the core would have been acceptable under the worst case conditions for which it was designed. The examination of spent nuclear fuel from each core provides the assurance needed that there are no unexpected technical issues not evaluated and addressed in the models that would affect continued unrestricted operation.

Data from examinations also contribute significantly to improvements in reactor design. Improvements in calculational models and analyses have enabled the Program to increase both the lifetime and the performance of reactor cores. For example, the reactor cores installed in the USS NAUTILUS in the 1950's operated for 2 years. Current reactor cores are designed to last over 20 years, a significant technical accomplishment unique to naval fuel. The Navy is seeking to develop a life-of-the-ship (30-year) core for the New Attack Submarine which is still in the design stages. This core will further reduce the amount of spent fuel generated in the long-term, as ships will not require refueling during their lifetime. Continuing data from current core types are essential if this effort is to succeed.

In the final analysis, examination of naval spent nuclear fuel absorbs considerable resources. In a time of extremely tight budgets, the Navy would not be performing such examinations unless they were judged to be necessary to support the conduct of technical work. Examinations done over the last 37 years have played a key role in achieving over 4500 reactor-years of safe nuclear reactor operations, having nuclear-powered warships steam over 100,000,000 miles, and increasing core lifetimes from 2 years to over 20 years. The record shows there is no reason for reducing the technical basis upon which safe naval reactor design and operation are founded, and that basis includes, as a key cornerstone, the examination of naval spent nuclear fuel.

A limited quantity of naval fuel is retained following examination for reference and further study. After examination, most spent fuel is loaded into shielded containers and transferred to the DOE's Idaho Chemical Processing Plant (ICPP) at the INEL for storage. The transportation of naval spent nuclear fuel from shipyards and prototypes is described in Attachment A. The receipt and handling at ECF of the spent fuel from naval reactors is described in Attachment B.

The Naval Nuclear Propulsion Program evaluates small samples of both fuel and non-fuel materials for possible use in naval reactor systems. The samples are irradiated at the INEL Test

Reactor Area and then examined at ECF. A typical sample undergoes several cycles of irradiation and examination over several months or years.

The basic process for managing naval spent nuclear fuel starts with the spent fuel from the reactor plant loaded in a container. There are many stringent control steps in the actual process that are necessary to ensure the safety and health of the workers, the public, and the environment. These controls have been established by the conservative philosophy of the Naval Nuclear Propulsion Program and, as a minimum, meet the applicable regulations of federal and state agencies. Those controls will also apply to any and all of the alternatives that are being considered for the management of naval spent nuclear fuel.

Historically, the main steps that have been used for many years for managing spent fuel consist of the following:

Step 1. The process starts with spent fuel that has been removed from the reactor and loaded in a shielded shipping container at a prototype site or shipyard authorized to perform naval reactor refuelings or defuelings.
Step 2. The loaded shipping container is transported by rail to the ECF at the INEL.
Step 3. The spent fuel is received at ECF.
Step 4. The spent fuel is separated from structural material and examined in the ECF water pool.
Step 5. The spent fuel is transferred, in a shielded container, to the ICPP.

At the ICPP, naval spent nuclear fuel is stored in water pools to shield workers from radiation. Naval nuclear fuel is designed to operate for decades in high-temperature water without substantial corrosion. This means that it can be stored in the cool water in storage pools with very, very little corrosion for centuries because the rate of corrosion, which is very slow at the temperatures inside naval reactors, decreases rapidly as the temperature of the water around the fuel decreases. Experience at the Expended Core Facility and the Idaho Chemical Processing Plant has shown that naval spent nuclear fuel has not degraded during many years in water pools.

2.4.2 Facilities Related to Naval Spent Nuclear Fuel

The shipyards that perform the refueling and defueling operations are also responsible for shipping the naval spent nuclear fuel to the facility where structural material is removed and examinations are conducted. Since 1957, these operations have been conducted at the ECF at INEL. After the specified operations and examinations are complete, ECF is responsible for transferring the spent fuel to ICPP, the storage location.

The operations at the shipyards for removing the spent fuel from the ship require the use of special, heavily shielded equipment to remove the spent fuel from the reactor to the shipping container (which is also heavily shielded) while protecting the workers from the radiation from the spent fuel. The shipping containers are designed and tested to transport the spent fuel by rail while protecting the workers and any nearby persons from the radiation of the spent fuel. At ECF, the spent fuel is unloaded from the shipping containers with special, heavily shielded transfer casks to protect the workers from radiation. The spent fuel is removed from the transfer cask in the water pool where the depth of the water is sufficient to shield the workers from the radiation of the exposed spent fuel modules. The subsequent machining operations and examinations of the spent fuel are performed in the water pool under the required depth of water, or in a heavily shielded cell where certain operations and examinations can be performed safely. After the work on the spent fuel is completed, the spent fuel is loaded into a shielded transfer cask (under water) for transit to the storage location, such as the ICPP. These are the main pieces of special equipment and facilities that are required to perform the necessary operations with naval spent nuclear fuel. There are many other pieces of equipment and apparatus that are also used along with the main equipment to do the necessary work safely and efficiently.

2.5 PLANNED REDUCTIONS IN THE NUMBER OF NUCLEAR-POWERED NAVAL VESSELS

Following the successful operation of the USS NAUTILUS in 1954, the number of nuclear-powered submarines and surface ships in the U.S. Navy grew steadily until it reached a peak of just over 150 ships in 1987. Report NT-94-2 provides a graph of the total number of nuclear-powered vessels in the U.S. Navy over the years since the beginning of the Naval Nuclear Propulsion Program

(NNPP 1994b). Since 1988, the number of nuclear-powered vessels in the U.S. Navy has decreased. The Navy has been able to accomplish its mission with fewer ships, partly because the ships and crews became more capable over the years and partly because the development of longer-lived nuclear reactor cores makes it possible for nuclear-powered ships to spend more time on duty and less time in shipyards being refueled. A major factor in the reduction in the number of nuclear-powered vessels is that, since the end of the Cold War, the Navy has embarked on a program to reduce the number of warships in its fleet. With the Navy downsizing from a fleet of almost 600 warships to a fleet of just over 300, the number of nuclear-powered warships is also diminishing. The actual size of the nuclear-powered fleet by the year 2000 is expected to be between 80 and 90 vessels having between 95 and 110 reactors (since surface ships have two or more reactors).

Figure 2-1 shows the peak number of nuclear-powered naval vessels in 1987 and the number of nuclear-powered ships in the fleet for each of the next 10 years under current planning. This planned reduction reflects the most recent changes in the mission of the U.S. Navy, including the effects of the end of the Cold War. Under this plan, the number of nuclear-powered naval vessels will be reduced by the end of the next 10 years to approximately one-half the number at its peak. The Navy is moving ahead with this plan, but it should be remembered that such plans may change in the future if Congress alters the Navy's mission in the light of world developments.

This plan for reducing the number of nuclear-powered naval vessels was used in the development of environmental impacts in this Environmental Impact Statement (EIS). For example, the planned reduction in the number of ships in future years is incorporated into all of the impacts associated with examination or storage of naval spent nuclear fuel reported in this EIS. Similarly, the timing and number of naval spent nuclear fuel shipments used in the calculation of impacts associated with transportation are based on this plan.

Figure 2-1. Total number of nuclear-powered ships in the United States Navy. 2.6 REFERENCES

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3. ALTERNATIVES

This section describes the alternatives which were evaluated for the management of naval spent nuclear fuel removed during reactor refuelings and defuelings at naval and commercial shipyards and at the prototype sites. Since Chapter 3 of Volume 1 provides a complete description of the Department of Energy's alternatives for all types of spent nuclear fuel under its cognizance, the descriptions in this section are limited to aspects of the alternatives related to naval spent nuclear fuel.

1. No Action: Spent fuel from naval reactors at naval shipyards and prototype sites would be stored in shielded containers at facilities close to the refueling and defueling sites. There would be no spent fuel examinations.

2. Decentralization: There are three different variations to this alternative. The first is similar to the No Action alternative except that additional spent fuel storage options would be pursued. In the second variation, a limited amount of spent fuel would be examined in detail at Puget Sound Naval Shipyard to provide information on nuclear fuel performance. This limited amount of fuel would be stored at the examination site and the remainder would be stored at or near the refueling

and defueling sites. In the third variation, all spent fuel would be shipped to the Idaho National Engineering Laboratory (INEL) Expended Core Facility (ECF) and examined as it has been in the past, then returned for storage to facilities at or near the refueling and defueling sites; all planned ECF improvements, including the dry cell expansion (Attachment B), would be completed.

3. 1992/1993 Planning Basis: Spent fuel would continue to be received, examined, and stored at INEL as it has been in past years. All planned ECF improvements, including the dry cell expansion (Attachment B), would be completed.

4. Regionalization: Current and future naval spent nuclear fuel would be received, examined, and stored at the Hanford Site, INEL, the Savannah River Site, the Nevada Test Site, or the Oak Ridge Reservation. If INEL were the site selected for Regionalization of naval spent nuclear fuel, then this alternative would be essentially the same as the 1992/1993 Planning Basis alternative.
5. Centralization: Current and future spent fuel would be collected and stored at one Department of Energy (DOE) site. Examination and storage facilities would be constructed, as necessary. All examinations would be performed at that one site. There would be no difference between the Regionalization and the Centralization alternatives for naval spent nuclear fuel.

This section also describes other alternatives which were considered and then eliminated from detailed analysis.

3.1 NO ACTION

This alternative is restricted to the minimum actions deemed necessary for continued safe and secure handling and storage of naval spent nuclear fuel. It is important to note that this alternative is not a status quo condition. Naval reactors would be refueled and defueled as planned. Naval spent nuclear fuel would be stored in shipping containers at a Navy or DOE facility. These shipping containers would be modified and recertified as discussed in Section D.1.2.1 of Attachment D. No further naval spent nuclear fuel examination would be conducted and research and development activities associated with examination of the spent fuel would not be performed. The Expended Core Facility at INEL would be shut down.

Under this alternative, the transportation of naval spent nuclear fuel to INEL would be ended after about 3 years, during which additional shipping containers would be purchased and actions to prepare naval sites to serve as storage locations would be completed (see Section 3.8). The spent fuel from naval reactors at naval shipyards or active prototype sites would be stored at a naval shipyard or prototype, in most instances where it was removed from the reactor during servicing. The spent fuel would be removed from the reactors and placed directly into shipping containers for storage without detailed examination.

Newport News Shipbuilding, a private shipyard located in Newport News, Virginia, does refueling and defueling work for the Navy. Spent fuel removed from ships refueled or defueled at Newport News Shipbuilding would be transported to the nearest naval site, Norfolk Naval Shipyard, in Portsmouth, Virginia. Norfolk Naval Shipyard is about 10 miles (about 250 miles by rail) from Newport News Shipbuilding. The spent fuel would be stored in such a way that it would be protected from damage or intruders and that workers, the public, and the environment would be protected. The fuel would remain in storage until the DOE is prepared to take receipt of the fuel.

Since no additional spent fuel examinations would be performed at ECF, the work associated with examination of test specimens irradiated in the Advanced Test Reactor at INEL would be transferred to another site at INEL. The selected site might require modifications to accommodate this work.

If this alternative and its minimum actions were selected, it would be necessary to construct and certify approximately 500 additional shipping containers and to construct the associated rail spur tracks for the naval sites to be able to store the spent fuel from all of the nuclear-powered ships that will be refueled or defueled until the time that a permanent disposal facility becomes operational. During the period of time when containers would not yet be available, naval spent nuclear fuel would be transported in shipping containers to the Expended Core Facility at INEL. These containers would be unloaded and used to support additional refuelings and defuelings.

A major result of this and any other alternative which precludes detailed examination of naval spent nuclear fuel is that the further development of improved nuclear fuel for U.S. Navy ships would be hindered. Examination of spent fuel provides useful information on the performance of existing fuel system designs. Without a continuing flow of such information, eventually confidence in the ability of naval nuclear fuel to perform satisfactorily under design conditions would decrease. This information is also important in developing improvements in future fuel designs.

In this context, an alternative which would leave the spent nuclear fuel onboard nuclear-powered warships was considered. Under such an alternative, refueling and defueling operations would cease and the nuclear-powered warships would be retired in place at piers at Navy facilities. As discussed in Section 3.6.3 of this Appendix, it was determined that this approach to a "no action" alternative would actually involve many actions, including a large expansion of pier space, with the resultant ecological impacts, an increased number of naval personnel assigned to monitoring the retired nuclear-powered ships, a large reduction in work force at several shipyards, and a reduction in the number of operating nuclear-powered warships beyond that planned. Consequently, it was concluded that this could not be considered a "no action" alternative and a more appropriate, and feasible, approach for the No Action alternative was used as a basis for this Environmental Impact Statement.

Attachment D contains a more detailed description of storing naval spent nuclear fuel at or close to its removal location.

3.2 DECENTRALIZATION

Under this alternative, DOE would maintain existing naval spent nuclear fuel in storage at INEL, and new naval spent nuclear fuel would be stored at or near the sites where it was removed from reactors. Three different variations of this Decentralization alternative have been considered. In general, these variations are similar to the No Action alternative with regard to their location and method for long-term storage of spent nuclear fuel. At each storage location under all three options, storage in shipping containers, dry storage casks, and wet storage in water pools has been considered. All of them would require a transition period while facilities are developed (see Section 3.8).

3.2.1 Store Naval Spent Nuclear Fuel at or Close to Locations Where

Removed Without Examination

Similar to the No Action alternative, this alternative would include storage of the spent fuel from reactors at naval shipyards or active prototype sites close to the locations where it was removed during refueling or defueling. The spent fuel would be placed directly into storage without detailed examination. Storage would be in water pools, dry casks, or shipping containers. The spent fuel would be protected from damage or intruders, and workers, the public, and the environment would be protected. The fuel would remain in storage until a permanent disposal site became available.

No further naval spent nuclear fuel examination would be conducted. Without this examination program, further development of improved nuclear fuel for U.S. Navy ships would be hindered. Naval spent nuclear fuel examination provides useful information on the performance of existing fuel system designs. A continuing flow of such information is needed to prevent confidence in the ability of naval nuclear fuel to perform satisfactorily under design conditions from decreasing over time. Information from examination of naval spent nuclear fuel is also important in developing improvements in future designs. In addition, the work associated with examination of irradiated test specimens, which is also essential to the development of advanced designs, would no longer be performed at the Expended Core Facility at INEL and would have to be relocated to other facilities at INEL. The Expended Core Facility at INEL would be shut down.

The environmental effects associated with this alternative would be determined primarily by the choice among water pool, dry storage casks, or shipping container storage. The shipping containers could be mobile storage casks, which could also be used for shipping. Like the other options under this alternative, a transition period would be required during which it would be necessary to design, construct, and certify enough shipping containers or dry storage casks to store the spent fuel from all nuclear-powered ships being refueled or defueled or to design, construct, and certify water pools for fuel storage at naval sites. During this transition period, naval spent nuclear fuel would continue to be shipped to the Expended Core Facility at INEL where the shipping containers would be unloaded and used to support additional refuelings and defuelings.

Attachment D contains a more detailed description of storing naval spent nuclear fuel at or close to its removal location.

3.2.2 Examine a Limited Amount of Naval Spent Nuclear Fuel in the

Puget Sound Naval Shipyard Water Pit Facility and Store All Naval Spent Nuclear Fuel at Navy Facilities

Under this alternative, the existing water pool facility at Puget Sound Naval Shipyard, originally built to support the refueling of nuclear-powered aircraft carriers, would be modified to conduct the maximum amount of naval spent nuclear fuel examinations practical at that site. The difference between this alternative and the one described in the preceding section is that only a small amount of spent nuclear fuel could be examined to provide information on nuclear fuel performance for use in the development of improved nuclear fuel.

The only existing facility available within the Naval Nuclear Propulsion Program, other than the facility at ECF, which could be used to examine spent fuel from naval reactors is the water pool at the Puget Sound Naval Shipyard at Bremerton, Washington. However, the use of this facility for visual and dimensional examinations of high-priority spent fuel assemblies would require removal of the presently installed aircraft-carrier refueling equipment. As a result, Puget Sound would no longer have the capability to refuel nuclear-powered aircraft carriers. This facility has no shielded cells for performing destructive examinations of spent fuel. Although this alternative would provide a limited capability for examination and analysis of spent fuel, the ability to sustain further development of the advanced nuclear reactors needed to ensure the safety and performance superiority of U.S. Navy ships would be jeopardized. Continuous performance of naval spent nuclear fuel examinations at Puget Sound Naval Shipyard would preclude the performance of aircraft-carrier refuelings at Puget Sound because the needed water pit would no longer be available.

The limited amount of spent fuel examined in the modified facility and all naval spent fuel removed from reactors at Puget Sound Naval Shipyard would be stored at that shipyard. The naval spent fuel removed at other naval shipyards or active prototype sites would be stored at a site close to the location where it was removed during refueling or defueling. The limited amount of fuel to be examined would be transported from the originating site to Puget Sound Naval Shipyard in the shipping containers currently used for naval spent nuclear fuel.

Like the other options under this alternative, a transition period would be required for development of facilities utilizing shipping containers, dry storage casks, or water pools for fuel storage at naval sites. During this transition period, naval spent nuclear fuel and test specimens would continue to be shipped to the Expended Core Facility at INEL where the shipping containers would be unloaded and used to support additional refuelings and defuelings.

Under this option, the Expended Core Facility at INEL would be shut down after the end of the transition period. The examination of irradiated test specimens would be performed as discussed under the No Action alternative (Section 3.1).

Attachment D contains a more detailed description of the examination and storage of naval spent nuclear fuel for this alternative. The transportation of fuel to be inspected at Puget Sound Naval Shipyard is described in Attachment A.

3.2.3 Examine All Naval Spent Nuclear Fuel at the INEL and Return to

Naval Facilities for Storage

Under this option, all naval spent nuclear fuel would be shipped to the Expended Core Facility at the INEL for examination. After examination, this fuel would be returned to a naval or DOE facility for long-term storage near the location where the fuel was removed from a reactor. The examination of spent fuel under this alternative would be performed at the INEL Expended Core Facility as has been done in past years. As with other options under this alternative, the naval spent nuclear fuel would be stored in shipping containers, dry storage casks, or water pools. All planned improvements to the Expended Core Facility, including the dry cell expansion, would be completed.

The receipt, examination, and preparation for storage for this alternative would be the same as described in more detail in Attachment B, and the storage would be the same as that described in Attachment D for shipyard and prototype storage. Transportation of the spent fuel would be accomplished in the same manner as described in Attachment A.

3.3 1992/1993 PLANNING BASIS

The practice of transporting spent nuclear fuel removed from naval reactors to the Expended Core Facility in Idaho for examination would be resumed. Following examination, the spent nuclear fuel would be transferred to DOE for management at the Idaho Chemical Processing Plant pending final disposition. All planned improvements in fuel examination capability for naval spent nuclear fuel at INEL, including the ECF dry cell expansion, would be completed. Operation of an ECF Dry Cell Facility is included in the supporting analysis and the assumptions of this Environmental Impact Statement.

The shipment of naval spent nuclear fuel from shipyards and prototypes to INEL is described in Attachment A, and receipt and handling at INEL of the spent fuel from naval reactors and active prototypes is described in Attachment B. Attachment B also includes a description of the ECF Dry Cell Facility.

3.4 REGIONALIZATION

Two options have been considered under this alternative. Under the first Regionalization option considered, DOE would manage all spent nuclear fuel at the Hanford, INEL, and Savannah River sites, allocating each type of spent nuclear fuel to one of these sites according to its characteristics, such as the type of cladding. Under the second option, spent nuclear fuel under DOE cognizance would be managed at one DOE site in the eastern portion of the United States and one DOE site in the western part of the United States, with all spent nuclear fuel assigned to one of these two sites on the basis of its point of origin. The eastern site would be either the Savannah River Site or the Oak Ridge Reservation, and the western site would be the Hanford Site, INEL, or the Nevada Test Site. The Expended Core Facility at INEL would be shut down in all cases where INEL would not be used for naval spent nuclear fuel examination and storage.

3.4.1 Regionalization Using Storage at Three Sites (Hanford, INEL,

and Savannah River)

This option under the Regionalization alternative would result in all naval spent nuclear fuel being managed at the INEL in the same manner as the 1992/1993 Planning Basis alternative because all naval nuclear fuel has similar characteristics and would be managed at a single site. Under DOE plans, all Zircaloy-clad fuel would be managed at the INEL and since naval fuel is Zircaloy-clad, it would be assigned to INEL. The practice of transporting spent nuclear fuel removed from naval reactors to the Expended Core Facility in Idaho for examination would be resumed. Following examination, the fuel would be transferred to DOE for management at the Idaho Chemical Processing Plant pending final disposition. All planned improvements in fuel examination capability for naval spent nuclear fuel at INEL would be completed.

3.4.2 Regionalization Using Storage at Only Two Sites

Under this option, DOE would collect all spent nuclear fuel at one existing large DOE site in the eastern United States (either the Oak Ridge Reservation or the Savannah River Site) and at one existing large DOE site in the western part of the country (either the Hanford Site, INEL, or the Nevada Test Site). Spent nuclear fuel would be collected at one or the other of these two sites, based on its original location. Only one of the two locations would be used for examination and storage of naval spent nuclear fuel under this option, but the impacts of managing naval spent nuclear fuel at all of the possible sites have been evaluated because the site for naval spent nuclear fuel has not been chosen.

A new naval spent nuclear fuel examination facility would have to be constructed at the site selected if it were other than INEL, and the Expended Core Facility at INEL would be shut down. The new facility would have capabilities equivalent to those of the existing Expended Core Facility at INEL and would support all examinations and experimental work required for the development of naval reactors. The new examination facility would be operated by the Naval Nuclear Propulsion Program.

Naval spent nuclear fuel would be removed from naval reactors and transported by rail to the new examination facility, as described in Attachment A. The fuel would be unloaded and examined in the water pools and shielded cells constructed for this purpose, in a manner similar to that described in Attachment B. After completion of all examination work, the naval spent nuclear fuel would be transferred to storage facilities operated by the DOE at the same site. None of the DOE sites considered in this alternative, other than INEL, currently has facilities adequate to store the amount of spent nuclear fuel involved in this option. Therefore, the DOE would have to construct new storage facilities suitable for spent nuclear fuel, including naval spent nuclear fuel, if this option were selected.

It should be understood that the Navy would operate only one facility for examination of all naval spent nuclear fuel, and all naval spent nuclear fuel examined during the period covered by this Environmental Impact Statement would be stored at the same DOE site where the examinations would be performed. Therefore, there are no differences for management of naval spent nuclear fuel between the Regionalization alternative and the Centralization alternative (described in the next section) for the same site.

3.5 CENTRALIZATION

As implied by its name, this alternative would collect all current and future DOE spent nuclear fuel at one DOE site. The sites analyzed include the Hanford Site, INEL, the Savannah River Site, the Oak Ridge Reservation (ORR), and the Nevada Test Site (NTS). As in the Regionalization alternative, the Navy would operate a facility for examination of naval spent nuclear fuel at only one DOE site, and all naval spent nuclear fuel examined during the period evaluated would be stored at the DOE site where it was examined, so there are no differences between the Regionalization alternative and the Centralization alternative for management of naval spent nuclear fuel.

If INEL were chosen as the DOE site for centralized long-term storage of naval spent nuclear fuel, the Expended Core Facility would continue to operate. After examination at the Expended Core Facility, naval spent nuclear fuel would be transferred to the Idaho Chemical Processing Plant. There would be no need to modify the Expended Core Facility since it is a safe, modern facility providing all the capabilities needed for naval spent nuclear fuel examinations. However, any planned facility changes to provide improved or additional fuel handling and examination capability, such as the ECF Dry Cell Facility, would be completed.

If a DOE site other than INEL were chosen for the centralized long-term spent nuclear fuel storage facility, then the Expended Core Facility at INEL would be closed. A new naval spent nuclear fuel examination facility would need to be constructed at the selected site, or an existing facility would have to be modified to perform the needed examinations of naval spent nuclear fuel. This facility would provide capabilities equivalent to those of the existing Expended Core Facility at INEL. Similarly, additional spent nuclear fuel storage facilities would have to be constructed at the selected site since there are insufficient facilities at other sites suitable for storage of spent nuclear fuel from INEL.

Adjacent to the Savannah River Site is the site of the Barnwell Nuclear Fuel Plant. This privately owned facility is not being used currently. It could be purchased at an undetermined price, annexed to the Savannah River Site, and subsequently modified to provide capabilities equivalent to those at the Expended Core Facility. Similarly, at Hanford there exists the Fuels and Materials Examination Facility (FMEF) that could be modified to provide capabilities equivalent to those at the Expended Core Facility. It is expected that the modifications to either of these two facilities would cost less than the construction of a new Expended Core Facility.

Shipments of naval spent nuclear fuel to the Expended Core Facility in Idaho would resume during the first 3 years of the time required to construct a new naval spent nuclear fuel examination facility at the selected location (see Section 3.8). All naval spent nuclear fuel would be transferred to the central site after the new facilities were placed into operation.

The receipt, handling, and storage of naval spent nuclear fuel for this alternative are described in

Attachments B and E, and transportation of the spent fuel is described in Attachment A.

3.6 ALTERNATIVES ELIMINATED FROM DETAILED ANALYSIS

Several other alternatives were considered in addition to those described above. However, these other alternatives were not analyzed to the same depth as those described above. These alternatives and the reasons for not analyzing them in detail are discussed in this section.

3.6.1 Use Other Combinations of Sites for Examination and Storage

of Naval Spent Nuclear Fuel

Some variations of alternatives can be conceived in which spent fuel would be shipped from the site at which it was removed from a reactor to some other facility for examination or preparation for storage and subsequently shipped to another facility for storage. Evaluating all such combinations for examination, treatment, and storage as separate alternatives would be complicated because of the large number of alternatives which could result. Furthermore, detailed treatment of such a large number of alternatives would complicate the evaluation of environmental effects.

However, it is not necessary to consider each of these combinations individually because the processes involved and the possible environmental effects generally can be represented by combinations of the effects of alternatives already discussed. For example, the impacts of examining spent fuel at a DOE site other than INEL followed by shipment back to a shipyard for storage would be essentially the same as those for examination of fuel under the alternative of examination and storage of the fuel at the alternate DOE site, described in Section 3.5, except for transportation. Continuing the example, the effects of storing the naval spent nuclear fuel at a shipyard as part of such an alternative would be the same as those for storing spent fuel at the shipyard without inspection, described in Section 3.2.1. The effects of shipping the fuel back and forth between the DOE site and a shipyard for such an approach would be approximately double the effects of shipment to the DOE site for inspection and storage because the same sites are involved but a second trip would be required to return the fuel from the inspection site to the storage site.

In a similar fashion, the effects of other possible combinations of inspection and storage sites can be deduced from combinations of the alternatives discussed in earlier sections. In order to avoid complication and confusion, these alternative combinations were not explicitly analyzed in this statement.

3.6.2 Examine or Store Spent Nuclear Fuel from Naval Reactors in

Foreign Facilities

It would be physically possible to examine and store spent nuclear fuel from naval reactors in foreign countries. The naval spent nuclear fuel could be shipped safely to a foreign country and safe storage could be established. However, the characteristics of naval fuel are classified pursuant to the requirements of the Atomic Energy Act of 1954, as amended. Such characteristics include the fuel's geometry, what requirements govern its design, how it is manufactured, and how it operates in a naval reactor. These characteristics can be deduced from physical nondestructive examination of the fuel and from more intrusive means of inspection.

Information classified under the Atomic Energy Act may not be provided to foreign governments or foreign interests unless the President determines that such access is in the defense interests of the United States, a government-to-government agreement allowing such access is reached, and proper Congressional review is afforded to ensure acceptance by the legislative branch.

Characteristics of long-lived U.S. naval fuel, which constitutes virtually all of the naval spent nuclear fuel evaluated in this Environmental Impact Statement, have never been provided to any foreign country. It has been long-standing U.S. policy not to provide such information and there is no agreement currently in existence with any foreign country providing for such access.

U.S. naval fuel also utilizes highly enriched uranium suitable for use in nuclear weapons. Naval spent nuclear fuel remains highly enriched even after it has completed use in a naval reactor. As such, the Nuclear Non-Proliferation Act, implementing requirements of the Treaty for the Non-Proliferation of Nuclear Weapons, imposes severe restrictions on the transfer of such material to foreign countries. These restrictions are in addition to those arising from the classified nature of the fuel described above.

Foreign nations provide no unique capabilities or advantages for examination or storage of naval spent nuclear fuel. In fact, only four other countries (the United Kingdom, France, Russia, and the Peoples Republic of China) build and operate nuclear-powered warships, and none has naval reactor fuel having the long-lived performance characteristics of U.S. naval reactor fuel. Thus, U.S. capabilities for the examination of such long-lived fuel are unique and special.

There are also technical and environmental reasons why processing of naval spent nuclear fuel in foreign facilities is unreasonable. As is discussed in this Environmental Impact Statement, naval spent nuclear fuel is not expected to require any processing or stabilization - it will likely be suitable for direct emplacement in a geologic repository owing to its inherent structural strength and integrity, made necessary by its military application. Processing naval spent nuclear fuel is more difficult than commercial or DOE fuel for those same reasons, and doing such reprocessing abroad would result in the production of highly enriched uranium in a foreign country, creating concerns over non-proliferation and nuclear material safeguards.

Based on these considerations, the alternative of processing or storing naval spent nuclear fuel in foreign countries is not a reasonable alternative, and thus was eliminated from detailed analysis.

3.6.3 Do Not Remove Naval Spent Nuclear Fuel from Nuclear-powered Ships

Nuclear-powered warships represent about 40 percent of the Navy's major combatants. The size of the Navy fleet is based on ensuring that the Navy has sufficient ships in active service at all times to meet the country's defense commitments, as established by Congress and the President.

It is physically possible to retain spent fuel in the reactors in nuclear-powered vessels and moor the ships at shipyards until a decision on the ultimate disposition of spent nuclear fuel is reached, making those ships for which refueling was planned unavailable for further service. However, this approach would result in these ships being unavailable once their currently installed reactor fuel reaches the end of useful life. This is impractical because the ships would have to be replaced (a process that of necessity takes many years and in most instances requires ships that have not been designed) or the Navy would be forced to operate without the full complement of ships required to execute national policies. Since the entire submarine fleet is nuclear-powered, including the fleet of ballistic missile submarines which comprise the least vulnerable part of the nation's strategic deterrent, and our attack submarines which seek out opposing ballistic submarines as well as play a crucial role in littoral warfare, failure to refuel these units would result in a unilateral decrease in the nation's strategic deterrent.

Also of particular importance in this regard is the commencement of refueling NIMITZ Class aircraft carriers which form the backbone of the Navy's fleet. Of twelve operating carriers, six are NIMITZ Class, with three more under construction to replace older, conventionally powered carriers scheduled for retirement. Refueling of the USS NIMITZ is scheduled to begin in 1998, but refueling preparations are already underway for this first-of-a-kind effort. These preparations entail emptying, by late 1995, spent nuclear fuel from the earlier refueling of the USS ENTERPRISE and defueling of the USS LONG BEACH. This spent nuclear fuel is at Newport News Shipbuilding and Drydock Co. in a special support facility which is required for the NIMITZ Class refuelings. Once the facility is emptied, it would then be reconfigured for use, including refurbishment, maintenance, and extensive training of refueling personnel.

If the facility cannot be emptied, the USS NIMITZ and subsequent NIMITZ Class carriers (USS DWIGHT D. EISENHOWER, USS CARL VINSON, USS THEODORE ROOSEVELT, US ABRAHAM LINCOLN, and others) which are scheduled for refueling in succession after the US NIMITZ could not be refueled to rejoin the fleet at the time they would be required for service. In effect, the Navy would have far fewer carriers than would be needed to fulfill national security requirements. These requirements include maintaining continued forward presence in peacetime (which is essential to deter aggression, encourage global stability, and promote interoperability with our allies) and timely crisis response. National security requirements also include ability to field forces sufficient to engage in two simultaneous regional conflicts (such as Operation Desert Storm), as well as operations other than war, such as Somalia and Haiti. The national security need to ensure that the USS NIMITZ is refueled and returned to service in the fleet on schedule was certified by the Secretary of Defense in October 1994 and accepted by the Governor of Idaho in January 1995, when he allowed shipment of naval spent nuclear fuel from the Newport News Shipbuilding and Drydock Co. to continue. Additional shipments would be required after the Record of Decision is issued on this EIS in June 1995 to complete unloading the facility by late 1995.

Additionally, implementing this alternative would require extensive modifications to facilities at shipyards, including increasing the number of piers and the availability of waterfront utilities to support the ships at their moorings. Other shipyard facilities also might have to be modified or replaced as a result of the use of waterfront space to moor the numbers of ships involved during the 40-year period. The construction of piers and other needed facilities would cause impacts on the waterfronts and harbors and could affect the local ecology. For example, dredging would be required along with disposal of dredge spoils; such activities have been an environmental concern at several Navy facilities.

While this method for storing naval spent nuclear fuel would cause some increase in construction activities, in the long run it would result in the idling of skilled workers as the shipyards ran out of room and work schedules were disrupted by the loss of ship servicing work. Mooring the ships without removing the naval spent nuclear fuel would also utilize highly trained Navy nuclear ship operators in the unproductive task of watching over shutdown ships. The resources dedicated to providing the additional moorings would produce no improvements in a shipyard's ability to perform its mission and would actually decrease its capabilities. The radiological effects on the environment or people in the vicinity would be negligible as long as the nuclear-powered vessels and propulsion plants were maintained under the same procedures and discipline used for operating ships, since the environmental effects of operating U.S. Navy nuclear-powered vessels are well documented and known to be negligible.

Separately, the costs of maintaining the ships with spent nuclear fuel remaining installed under Navy operating procedures and providing the additional piers and waterfront services and utilities would be large. The costs of this approach would be high both for ships which are to be decommissioned and for ships which would normally be refueled and returned to duty. One cost would result from the need to assign qualified nuclear operators to monitor vessels awaiting refueling or defueling. In the case of ships which are being decommissioned at the end of their life, the primary cost of this alternative would be the cost to maintain qualified nuclear operators, shipboard equipment, and associated shipyard support, including security, to ensure nuclear and radiological safety for the workers and the public. This would be more expensive than removal of the spent fuel for storage.

Thus, in summary, this alternative would be costly and would involve extensive actions which would have an effect on the environment due to construction activities. This alternative would also not permit continued service of many Navy ships and only postpone decisions on a satisfactory storage location. As a result of these considerations, this alternative was eliminated from detailed analysis.

3.7 COMPARISON OF ALTERNATIVES

This section provides a comparison of the alternatives as they relate to the activities which fall under the Naval Nuclear Propulsion Program (NNPP). The comparison focuses on those areas which are projected to have the most significant impacts. As discussed in Sections 5.1 through 5.6, the impacts projected for most impact categories are very small or nonexistent. Such impact categories include: land use, cultural resources, aesthetic and scenic resources, geology, water resources, ecological resources, noise, utilities and energy, waste management, and irreversible and irretrievable commitment of resources. Consequently, the impacts in these areas provide no basis for distinguishing among alternatives.

It is important to note that in the No Action alternative and in two of the options of the Decentralization alternative, examination of naval spent nuclear fuel would cease or be seriously reduced and important scientific information would be lost. Beyond this issue, the principal differences among the alternatives occur in the categories of occupational and public health and safety (including normal operations and accidents for facility operations and transportation operations), cumulative impacts, and socioeconomics. Even in these areas, the overall impacts and the differences are small and represent the few unavoidable adverse effects that remain after the years of experience have been factored into the operations and the necessary mitigative measures have been applied.

DOE has adopted two quantitative safety goals to limit the risks of fatalities associated with its nuclear operations. The goals are:

- The risk to an average individual in the vicinity of a DOE nuclear facility for prompt fatalities that might result from accidents should not exceed one-tenth of one percent (0.1%) of the sum of prompt fatalities resulting from other accidents to which members of the population are generally exposed.

- The risk to the population in the area of a DOE nuclear facility for cancer fatalities that might result from operations should not exceed one-tenth of one percent (0.1%) of the sum of all cancer fatality risks resulting from all other causes.

A comparison of the calculated risks associated with each of the Naval Nuclear Propulsion Program alternatives indicates that the implementation of any of these alternatives would be well within the DOE facility safety goals.

3.7.1 Summary of Impacts

The most salient of the environmental impacts are summarized below. These impacts are presented under two categories:

- Human Health Impacts
- Other Impacts.

3.7.1.1 Human Health Impacts. Table 3-1 provides an overall comparison of the alternatives. This comparison is presented in terms of the increase in the number of cancer fatalities that could occur in the general population for any given year after an alternative has been implemented and has achieved a stable level of operation. This increase in the risk of developing fatal cancers is broken down to show how much risk increase is associated with normal operations, the highest risk facility accident, and transportation operations. For example, it is calculated that for the 1992/1993 Planning Basis alternative in which naval spent nuclear fuel would continue to be received, examined, and prepared for storage at the ECF at INEL, there would be:

- an increase of about 0.0000009 cancer fatalities per year for the general population around INEL (i.e., about one additional cancer fatality nationwide in 1,000,000 years among the 116,000 people who live within a 50-mile radius of INEL) due to normal ECF operations.
- an increase of 0.000026 cancer fatalities per year for the general population along the transportation routes due to normal transportation of naval spent nuclear fuel from the shipyards to the ECF.
- an increase of 0.00000017 cancer fatalities per year for the general population due to the facility accident with the highest risk (in this case it would be the accidental draining of a water pool used for examination and storage of naval spent nuclear fuel).

Table 3-1. Risk (fatal cancers to the general population per year) by alternative.

Alternative	Normal Operations Risk: Storage at NNPP Sites	Normal Operations Risk: Examination	Transportation Incident-Free Risk	Most Severe Facility Accident	Risk from a Transportation Accident Risk(3)
1. No Action	2.2 x 10-5	N/A	4.3 x 10-6	2.6 x 10-4	1.1 x 10-7
2. Decentralization					
- No Exam	2.2 x 10-5	N/A	4.3 x 10-6	2.6 x 10-4	1.1 x 10-7
- Dry Storage	3.4 x 10-4	N/A	4.3 x 10-6	1.1 x 10-5	1.1 x 10-7
- Water Pool Storage					
- Limited Exam	2.2 x 10-5	6.5 x 10-5	1.1 x 10-5	2.6 x 10-4	2.2 x 10-7
	2.7 x 10-4	6.5 x 10-5	1.1 x 10-5	1.1 x 10-5	2.2 x 10-7
- Dry Storage					
- Water Pool Storage					
	2.2 x 10-5	8.5 x 10-7	4.1 x 10-5	2.6 x 10-4	1.5 x 10-6
- Full Exam	3.4 x 10-4	8.5 x 10-7	4.1 x 10-5	1.1 x 10-5	1.5 x 10-6
- Dry Storage					
- Water Pool Storage					
3. 1992/1993 Planning Basis(1)		8.5 x 10-7	2.6 x 10-5	1.7 x 10-7	1.0 x 10-6
4/5. Regionalization or Centralization(1)(2)					
	-	8.5 x 10-7	2.6 x 10-5	1.7 x 10-7	1.0 x 10-6
- INEL	-	4.0 x 10-6	6.0 x 10-5	4.7 x 10-7	1.7 x 10-6
- Hanford	-	1.8 x 10-5	1.5 x 10-4	9.6 x 10-6	1.1 x 10-5
- S. River	-	9.0 x 10-8	7.5 x 10-5	7.2 x 10-8	7.5 x 10-6
- NTS	-	5.0 x 10-5	1.4 x 10-4	8.4 x 10-6	3.6 x 10-6
- ORR					

(1) For alternatives 3, 4, and 5, the risk due to storage of naval spent nuclear fuel is not included in

this evaluation. It is included in the evaluation of the individual DOE sites.

(2) Both the Regionalization and Centralization alternatives would locate an ECF at one of the five DOE sites. For this reason, the risk is the same for these alternatives.

(3) Some of the alternatives would involve a limited number of shipments by sea from Pearl Harbor to Puget Sound. Even though the probability of a severe accident involving a shipboard fire and release of radioactivity would be less than 10(-7) per year, the risk of such an accident has been calculated and is discussed in Attachment F, Section F.1.4.4. The risk of such an accident has been calculated to be 3.5 x 10(-6) per year.

- an increase of 0.000001 cancer fatalities per year for the general population due to risks of transportation accidents.

Table 3-1 shows that the cancer risks due to Naval Nuclear Propulsion Program activities for any of the alternatives are small. In all of these cases, thousands of years of repetition of the alternate action would be required before a single additional fatal cancer would occur. Risk is defined as the product of the probability of occurrence of an event leading to radiation exposure and the level of impact of exposure to radiation in terms of the increased number of fatal cancers that would result. A discussion of the key points in the development of an estimate of cancer fatalities is provided below; more detailed discussions of the parameters, analyses, and results are provided in Attachments A and F.

The increased number of fatal cancers is based on the calculated increase in exposure to radiation that would be seen by the general public as a result of each of the alternatives. The average annual exposure to a member of the population in the U.S. from background radiation is approximately 0.3 rem (300 millirem). The average annual collective exposure to all of the population in the U.S. from background radiation is approximately 69 million person-rem. When people are exposed to additional radiation, the number of additional radiation-induced cancer and other health effects needs to be considered. An estimate for radiation-induced cancer can be briefly summarized as follows:

- In a typical group of 10,000 persons who do not work with radioactive material, a total of about 2000 (20 percent) will normally die of cancer.

- If each of the 10,000 persons received an additional 1 rem of radiation exposure (10,000 person-rem) in their lifetime, then an estimated 5 additional cancer deaths (0.05 percent) might occur.

- Therefore, the likelihood of a person contracting fatal cancer during their lifetime could be increased nominally from 20 percent to 20.05 percent by exposure to 1 additional rem of radiation.

The "factor" for such a person to contract a fatal cancer, considering all possible organs, can be expressed as 0.0005 fatal cancers per rem of exposure. This is mathematically equivalent to 5.0 fatal cancers from 10,000 person-rem of collective exposure to a large group of persons.

Further, a collective exposure of 10,000 person-rem would be expected to produce, on the average, approximately 7.3 health detriments due to non-fatal and fatal cancers and severe genetic defects. These are two of the factors for the health detriments that may result from exposure to additional radiation. The results in this section are given in terms of fatal cancers. The total number of health detriments is the ratio 7.3/5.0 or 1.46 times these values.

The number of detrimental health effects which might result from exposure of a large group of people to low levels of radiation has been the subject of debate for many years. The calculations of health effects performed in this Environmental Impact Statement use the relation recommended by the International Commission on Radiological Protection because it is well-documented and kept up-to-date by the council. It also is widely accepted by the scientific community as representing a method which produces estimates of health effects that will not be exceeded. However, there are others who believe that exposure to low levels of radiation produces more health effects than would be estimated using the International Commission on Radiological Protection relation. On the other hand, a growing number of researchers believe that the International Commission on Radiological Protection relation overestimates the number of detrimental health effects produced by low levels of radiation. In fact, the possibility of no risk from the levels of radiation resulting from routine naval spent nuclear fuel management cannot be excluded (CIRRPC 1992). Clearly, using a relation developed by one or the other of these groups would produce a larger or smaller estimate of the number of health effects than the values presented in this statement. All of the results of analyses of normal operations and hypothetical accidents in Appendix D include the calculated exposure in addition to the number of health effects in order to permit independent calculations using any relation between radiation exposure and health effects judged appropriate.

The risks associated with all of the alternatives are low compared to the risks encountered in daily life. The risks of normal operations may be placed in perspective by considering other commonly encountered risks. For example, the average American is exposed to approximately 0.5 millirem each year from the radioactivity released from combustion of fossil fuels (NCRP 1987), which produces a lifetime risk of an average individual dying from cancer of about 1 chance in 50,000. As a further comparison, the naturally occurring radioactive materials in fertilizer used to produce food crops contribute about 1 to 2 millirem per year to an average American's exposure to radiation (NCRP 1987). This results in a risk of death from cancer between 1 chance in 12,500 and 1 chance in 25,000.

A frame of reference for the risks from accidents associated with spent nuclear fuel management alternatives can be developed by comparing them to the risks of death from other accidental causes. For example, the risk of death in a motor vehicle accident is about 1 chance in 80 (NSC 1993). Similarly, the risk of death for the average American from fires is approximately 1 chance in 500 and the risk of death from accidental poisoning is about 1 chance in 1000 (NNPP 1994b).

It must be remembered that no member of the public will receive as much as one one-thousandth of a rem from 40 years of the normal operations associated with any of the alternatives considered. Examining the results shown in the tables of radiation exposures (Attachments A and F) shows that the principal source of the difference in the exposures associated with radiation and radioactive materials released from normal operations and from hypothetical accidents for the alternatives is the number of people who live in the vicinity of the alternative sites and where they live relative to the facility itself. When the emissions from the sources are essentially the same, the resulting impacts depend directly on the size of the surrounding population, on the way the population is distributed around the site in terms of the distances and directions from the particular facility, and on the characteristics of the local meteorology.

3.7.1.2 Other Impacts. The principal impact in the employment portion of the socioeconomics

category is the number of jobs created by the construction and operation of a new (or modified) facility. The magnitude of the effect is relatively small in populations of the sizes under consideration, except to those people who benefit either directly or indirectly from the jobs. The creation of the jobs has some negative impacts: the jobs may be created at a distant location, or the jobs created locally may cause some small but adverse effect on the local community in terms of additional people and an increased need for additional public services.

The cost of operating and constructing new facilities or modifying existing ones to achieve the necessary capabilities for handling and storing spent fuel is an important economic impact. Depending on the site affected and the alternative under consideration, the cost may be as much as 5.7 billion dollars for construction and 40 years of operation.

In the unlikely event of a serious accident involving naval spent nuclear fuel, it is estimated that only about 210 acres of land would be affected for the most severe case (this is described in more detail in Attachment F), and in the other accidents analyzed, smaller areas of land would be affected. The affected area would require decontamination, and during this cleanup access controls would have to be established. However, due to the limited land area affected, it is judged that these restrictions would only be temporary and the impact on issues such as economics, treaty rights, tribal resources, ecology, and land use, would be relatively small and limited in time. The remediation actions would be simpler in rural areas than in urban areas; however, provided that prudent controls and remediation operations were promptly implemented, the affected land and buildings could be recovered in either case. As demonstrated in the accident analyses in Attachments A and F and summarized above, the human health effects are not large and the effects on wildlife and other biota would also not be large, partly due to the limited area affected.

Examination of naval spent nuclear fuel and irradiated test specimens has been conducted at the ECF at INEL since 1957. This program has made and continues to make important contributions to the safety, cost, and operational performance of naval nuclear propulsion plants. However, the No Action alternative and two of the Decentralization alternatives would result in substantial curtailment of this program. The Centralization, Regionalization, 1992/1993 Planning Basis, and the Decentralization - Full Examination alternatives would maintain the needed examination capability.

The safety of operating naval reactor plants has benefitted directly from the ECF examination programs. The result has been the construction of rugged reactor cores that are more tolerant of extreme conditions (such as corrosion, high temperatures, and intense radiation) without release of any fission products. The Naval Nuclear Propulsion Program's commitment to improved safety continues to be driven by two major issues:

- Protection of the Environment - In more than 40 years of operating and maintaining reactors in very demanding conditions, the Naval Nuclear Propulsion Program has never experienced a reactor accident, criticality accident, or a release of radioactivity that has had a significant effect on the environment.

- Personnel Safety - The importance of ensuring the integrity of the fuel is emphasized by the fact that the sailors onboard the ships live in very close proximity to an operating reactor 24 hours a day. Any release of radioactivity from the fuel into the reactor coolant would increase the radiation exposure of the ship's crew.

Since the inception of the Naval Nuclear Propulsion Program, the useful lifetime of naval reactors has been extended by more than a factor of 10. The examination programs at ECF played a major role in making this improvement possible. As a result of the extended reactor lifetimes, billions of dollars in ship refueling costs and spent nuclear fuel storage costs have been saved. In addition, longer reactor lifetimes permit the ships to spend a larger fraction of their lifetime on sea duty rather than in the shipyards, thus saving costs by reducing the number of ships required. Further reductions in nuclear propulsion plant costs are being pursued through improvements in many areas of nuclear fuel systems.

The improvements in nuclear fuel performance that have been developed in part through the knowledge gained from the examination program have contributed to improved ship operational characteristics. Major improvements have been made in power density, maneuverability, stealth, and simplicity. These improvements translate into important tactical advantages for our ships. Maintaining this advantage with ever improving technologies elsewhere in the world is vitally important to the safety of our sailors and to protecting our national interests.

In the final analysis, the most important differences are:

- The transfer of jobs associated with the Expended Core Facility among the alternative sites considered for locating the examination facility, or the outright loss of these jobs at INEL.
- The costs if new facilities are required.
- The loss or maintenance of naval spent nuclear fuel examination capability.

Sections 3.7.2, 3.7.3, and 3.7.4 provide additional summary information on the principal areas of impact.

3.7.2 Impacts Due to Normal Operations

During normal operations, there are public impacts due to direct radiation or due to the release of radioactive materials to the environment. These impacts are presented in the form of potential cancer fatalities due to exposure to the small amounts of radiation involved or radioactive materials released. It is important to emphasize that these cancer fatalities are calculated results rather than actual expected fatalities. This is because the expected number of such fatalities during normal operations is so small as to be unmeasurable and indistinguishable relative to the larger number of such deaths expected from naturally occurring conditions and other man-made effects not related to naval spent fuel operations. This is not meant to trivialize the importance of radiation-induced cancer fatalities but, rather, is meant to put the issue in perspective.

Table 3-2 presents a summary comparison of the calculational prediction of the number of fatal cancers per year that might be expected due to normal operations within each of the alternatives under consideration for naval spent nuclear fuel handling. This table provides the calculated impacts to the entire population. The impacts to selected individuals including workers are provided in Attachments A and F. Table 3-2 reflects the two possibilities (water pool and dry storage) for storing naval spent nuclear fuel at **the Navy sites.** In the case of dry storage at Navy sites, the impact from normal operations is due to calculated levels of direct radiation from storage casks at the shipyards. The environmental releases that were used to calculate the water pool values in the table are based on measured releases from the existing Expended Core Facility at the INEL. Also, the way in which direct radiation or environmental releases impact the population would be a function of the population distribution and the meteorological conditions present at the release location. To account for these differences, actual data on the population and meteorology for the various specific sites were used. The data in Table 3-2 are for a typical year in the future when the situation has stabilized at each location (that is, capabilities consistent with those described for the stated alternative have been achieved and are in operation at a facility at the indicated site).

All alternatives have some estimated number of fatalities, albeit a very small fraction. The lowest estimated number of cancer fatalities is associated with the 1992/1993 Planning Basis, Regionalization at INEL, and Centralization - INEL alternatives. The largest single estimate for the total number of cancer fatalities is only 0.00038 per year for the Decentralization - Full Examination alternative. Another way to view this is that if this alternative is selected and operations continue for

Table 3-2. Fatal cancers per year to the general population from normal operations.

Alternative	INEL	Puget Sound	Pearl Harbor	Portsmouth	Norfolk	Keesel-	Transpor-

```
ring    tation      Total

1.   No Action                -       1.2 x         9.3 x 10-        2.3 x      2.1 x 10-
4.1 x   4.3 x 10-6   2.7 x
                                      10-6          9                10-7       5
10-12                10-5
2.   Decentraliza-
tion

     -  No Exam               -       1.2 x         9.3 x 10-        2.3 x      2.1 x 10-
4.1 x   4.3 x 10-6   2.7 x
        - Dry Storage         -       10-6          9                10-7       5
10-12   4.3 x 10-6   10-5
        - Water Pool                  6.5 x         7.0 x 10-        2.3 x      1.4 x 10-
4.1 x                3.4 x
          Storage                     10-5          5                10-5       4
10-5                 10-4
                              -
1.1 x 10-5
                              -
1.1 x 10-5
     -  Limited Exam                  6.6 x         9.3 x 10-        2.3 x      2.1 x 10-
4.1 x                9.8 x
                                      10-5          9                10-7       5
10-12                10-5
        - Dry Storage      8.5 x      6.5 x         7.0 x 10-        2.3 x      1.4 x 10-
4.1 x   4.1 x 10-5   3.5 x
        - Water Pool       10-7       10-5          5                10-5       4
10-5    4.1 x 10-5   10-4
          Storage          8.5 x
                           10-7
     -  Full Exam                     1.2 x         9.3 x 10-        2.3 x      2.1 x 10-
4.1 x                6.4 x
                                      10-6          9                10-7       5
10-12                10-5
        - Dry Storage                 6.5 x         7.0 x 10-        2.3 x      1.4 x 10-
4.1 x                3.8 x
        - Water Pool                  10-5          5                10-5       4
10-5                 10-4
          Storage

                                                    Savannah
Alternative                INEL       Hanford       River            NTS        ORR
Transportation         Total

3.   1992/1993             8.5 x        -            -                 -          -
2.6 x 10-5   2.7 x
     Planning Basis        10-7
10-5
4/5. Regionalization
     or
     Centralization        8.5 x        -            -                 -          -
2.6 x 10-5   2.7 x
                           10-7       4.0 x          -                 -          -
6.0 x 10-5   10-5
     -  INEL                  -       10-6          1.8 x 10-          -          -
1.5 x 10-4   6.4 x
     -  Hanford                -         -           5                9.0 x       -
7.5 x 10-5   10-5
     -  S. River               -         -            -               10-8       5.0 x 10-
1.4 x 10-4   1.7 x
     -  NTS                   -         -            -                 -        5
10-4
     -  ORR
7.5 x

10-5

1.9 x

10-4
```

10,000 years, between three and four extra cancer fatalities might be expected in that entire time period due to normal operations.

3.7.3 Impacts Due to the Most Severe Accidents

Accidents may occur during operation of naval spent nuclear fuel handling and storage facilities and during transportation of naval spent nuclear fuel. Specific accidents considered to be more severe than all other reasonably foreseeable accidents were analyzed to determine their potential impacts on the general population. For sites with spent fuel storage in water pools, the facility accident analyzed was a drained water pool or an accidental criticality since these produced the greatest consequences. For sites with dry spent fuel storage, the facility accident analyzed was an airplane crash if its probability was greater than 1 x 10-7 per year (1 chance in 10 million per year); otherwise, a wind-driven missile was the accident analyzed. Details of analyses of foreseeable accidents which might occur during fuel handling and storage are described in Attachment F. Details of the transportation accident analyses are described in Attachment A.

In Table 3-3, the potential impacts of facility and transportation accidents with the greatest consequences are expressed in terms of fatal cancers per accident. These are calculated by using the relation that 0.0005 cancer fatalities could occur for each person-rem of exposure for the general population. The impacts are based on hypothetical occurrences of the accidents and do not reflect the very low probabilities of the accidents actually occurring. For each alternative, the maximum impact of either a facility or transportation accident is listed rather than a total of the individual impacts since it is reasonable that only one severe accident would occur at one time.

For facility accidents, the greatest potential impact is associated with dry spent fuel storage at the Pearl Harbor Naval Shipyard. This is due to an airplane crash into a dry storage container. For transportation accidents, the risks vary with the distances to be traveled, being least for the No Action and the Decentralization - No Examination alternatives which involve only minimal transportation to local storage.

Table 3-4 lists the most severe risks (probability of occurrence times the number of fatal cancers) from facility accidents in terms of potential cancer fatalities per year.

Table 3-3. Most severe consequences (fatal cancers to the general population) from an accident.+

Alternative	INEL(1)	Puget Sound(2)	Pearl Harbor(3)	Portsmouth(3)	Norfolk(3)	Kesslring(3)	Transportation(5)	Maximum
1. No Action*	-	0.017	26	9.0	16	7.5	0.013	26
2. Decentralization								
- No Exam	-	0.-	26	9.0	16	7.5	0.013	26
- Dry Storage	-	017	1.1	0.34	0.60	0.25	0.013	1.1
- Water Pool Storage		0.51						
	-		26	9.0	16	7.5	0.065	26
	-	0.017	1.1	0.34	0.60	0.25	0.065	1.1
- Limited Exam		0.51						
- Dry Storage	0.017		26	9.0	16	7.5	1.7	26
- Water Pool Storage	0.017	0.0- 17 0.51	1.1	0.34	0.60	0.25	1.7	1.7
- Full Exam								
- Dry Storage								
- Water Pool Storage								

Alternative	INEL(1)	Hanford	Savannah	NTS(4)	ORR(4)	Transportation	Maximum
3. 1992/1993 Planning Basis	0.017	-	-	-	-	2.1	2.1
4/5. Regionalization							

```
      or
      Centralization      0.017                   -             -                -          -
2.1          2.1
                          -                       0.047         -                -          -
2.1          2.1
      -  INEL             -                       -             4.8              -          -
2.1          4.8
      -  Hanford          -                       -             -                0.18       -
2.1          2.1
      -  S. River         -                       -             -                -          8.4
2.1          8.4
      -  NTS
      -  ORR
```

\+ Based on accidents with a probability of occurrence of 1 x 10-7 or greater.

* Dry storage is the only option considered under the No Action alternative.

(1) The most severe accident is a drained water pool.

(2) The most severe accident involving storage or examination in a water pool is a drained water pool.
For the dry storage alternatives, the most severe accident is mechanical damage from a wind-driven missile.
The limited exam - dry storage option at Puget Sound also includes examination in a water pool; the consequences
shown for this option are due to accidents occurring during dry storage operations only.

(3) The most severe accident is from a plane crash for dry storage and a drained water pool for water pool storage.

(4) The most severe accident is from a plane crash.

(5) Some of the alternatives would involve a limited number of shipments by sea from Pearl Harbor to Puget Sound.
Even though the probability of a severe accident involving a shipboard fire and release of radioactivity would be
less than 10-7 per year, the risk of such an accident has been calculated and is discussed in Attachment F,
Section F.1.4.4. The most severe consequences of such an accident have been calculated to be 51.5 cancer fatalities.

Table 3-4. Most severe risk to the general population from a facility accident.

```
                                         Puget         Pearl
Alternative               INEL(1)      Sound(2)      Harbor(3)        Portsmouth(3)
Norfolk(3)         Kesselring(3) Maximum
1.   No Action                  -      1.7 x         2.6 x 10-4       9.0 x 10-7
1.6 x 10-5         7.5 x 10-7   2.6 x 10-4
                                       10-7
2.   Decentraliza-
tion
     -  No Exam                 -      1.7 x         2.6 x 10-4       9.0 x 10-7
1.6 x 10-5         7.5 x 10-7   2.6 x 10-4
        - Dry Storage           -      10-7          1.1 x 10-5       3.4 x 10-6
6.0 x 10-6         2.5 x 10-6   1.1 x 10-5
        - Water Pool Storage           5.1 x
                                       10-6
                                -                    2.6 x 10-4       9.0 x 10-7
1.6 x 10-5         7.5 x 10-7   2.6 x 10-4
                                -                    1.1 x 10-5       3.4 x 10-6
6.0 x 10-6         2.5 x 10-6   1.1 x 10-5
     -  Limited Exam                   1.7 x
                                       10-7
        - Dry Storage     1.7 x        5.1 x         2.6 x 10-4       9.0 x 10-7
1.6 x 10-5         7.5 x 10-7   2.6 x 10-4
        - Water Pool      10-7         10-6          1.1 x 10-5       3.4 x 10-6
6.0 x 10-6         2.5 x 10-6   1.1 x 10-5
        Storage           1.7 x
                          10-7
     -  Full Exam                      1.7 x
                                       10-7
        - Dry Storage                  5.1 x
        - Water Pool                   10-6
        Storage


                                                     Savannah
Alternative               INEL(1)      Hanford(1)    River(4)         NTS(4)
ORR(4)                          Maximum
3.   1992/1993 Planning   1.7 x        -             -                -                          -
1.7 x 10-7
     Basis                  10-7
4/5. Regionalization or
     Centralization
                          1.7 x        -             -                -                          -
1.7 x 10-7
     -  INEL              10-7         4.7 x         -                -                          -
4.7 x 10-7
     -  Hanford           -            10-7          9.6 x 10-6       -                          -
```

9.6 x 10-6
- S. River - - - 7.2 x 10-8 -
7.2 x 10-8
- NTS - - - -
8.4 x 10-6 8.4 x 10-6
- ORR - -

* Dry storage is the only option considered under the No Action alternative.

(1) The most severe accident is from a drained water pool.

(2) The most severe accident involving storage or examination in a water pool is a drained water pool. For the dry storage alternatives, the most severe accident is mechanical damage from a wind-driven missile. The limited exam - dry storage option at Puget Sound also includes examination in a water pool; the risks shown for this option are due to accidents occurring during dry storage operations only.

(3) The most severe accident is from a plane crash for dry storage and a drained water pool for water pool storage.

(4) The most severe accident is from a plane crash.

3.7.4 Cumulative, Socioeconomic, and Cost Impacts

A summary of the estimated cumulative impacts from the radiological operations associated with each of the alternatives evaluated in detail is presented in Table 3-5. It is based on achieving a stable level of operation by 1995 for any given alternative. The impacts are expressed as fatal cancers to the population within 80 kilometers (50 miles) and apply to the reasonably foreseeable impacts for the 40-year period ranging from 1995 to 2035. The impacts were based on annual results for normal operations multiplied by 40. The impacts due to both wet and dry storage are presented. For the cumulative effect of storage at Navy shipyards and prototypes, the sum over all the Navy sites was used to provide a comparison for the same amount of fuel. The total for each alternative was then calculated by summing the fatal cancers for transportation, receipt and examination operations, and storage. The results show that the impacts for all alternatives would be negligible.

The historical impact of transportation and ECF operations for the period ranging from 1958 to 1995 was calculated to be about 0.001 fatal cancers. This is the total number of fatal cancers that are estimated among the several million people along transportation routes coupled with the 116,000 people located within 50 miles of INEL. This estimate was based on the calculated incident-free transportation results from Attachment A, and the calculated results of normal operations and storage from Attachment F. The calculated results from Attachment F were adjusted from an annual basis (1995) to the historical basis by multiplying by 38 years and by a factor of 1.7 to take into consideration the variations in the number of ships and operations. No extra factor was applied to the estimates of the historical impact or the future impact to account for the vulnerabilities that might be associated with facility or spent fuel aging because naval spent nuclear fuel is very strong and has very high integrity (Section 2.2), and historical experience has disclosed no important vulnerability. The factor of 1.7 represents the ratio of the average to the current radiation exposures received by all military and civilian personnel in the Naval Nuclear Propulsion Program during the historical period (NNPP 1994a). In the case of the Limited Examination alternative, the analysis includes both the material shipped to Puget Sound for examination and storage, as well as the material stored there and at other sites from defuelings without examination.

Table 3-6 presents the cumulative impact from the radiological operations to a hypothetical maximally exposed worker and a hypothetical maximally exposed individual at the site boundary. The impacts are presented in terms of the likelihood of fatal cancer for the affected individual. These

Table 3-5. Summary of cumulative impacts (fatal cancers to the general population).

Fatal Cancers (1995-2035)1
Storage3 Total

Alternative	Transport2	Exam Operations3	(Dry) [Wet]	(Dry) [Wet]
1. No Action	1.7 x 10-4	0	(9.0 x 10-4)**	(0.0011)**
2. Decentralization				
- No Exam	1.7 x 10-4	0	(9.0 x 10-4) [0.014]	(0.0011) [0.014]
- Limited Exam	4.2 x 10-4	0.0026	(9.0 x 10-4) [0.011]	(0.0039) [0.014]
- Full Exam	0.0017	3.4 x 10-5	(9.0 x 10-4) [0.014]	(0.0026) [0.015]
3. 1992/1993 Planning Basis	0.0011	3.4 x 10-5	*	0.0011
4/5. Regionalization or Centralization				
- INEL	0.0011	3.4 x 10-5	*	0.0011
- Hanford	0.0024	1.6 x 10-4	*	0.0026
- Hanford/FMEF	0.0024	1.6 x 10-4	*	0.0026
- S. River	0.0060	7.2 x 10-4	*	0.0067
- S. River/Barnwell Plant	0.0060	7.2 x 10-4	*	0.0067
- Nevada Test Site	0.0030	3.6 x 10-6	*	0.0030
- Oak Ridge Reservation	0.0055	0.0020	*	0.0075

Notes:
1 Fatal cancers for 1958-1995 were calculated to be about 0.001 for transport and ECF operations.
Fatal cancers were calculated at 5.0 x 10-4 fatal cancers per person-rem.
2 Values from Attachment A.
3 Values from Attachment F.
*DOE storage, not NNPP.
**There is no wet storage under the No Action alternative.

Table 3-6. Likelihood of fatal cancer from cumulative radiation dose.

	Maximally Exposed Worker		Maximally Exposed Individual	
	Total Radiation Dose (rem)	Likelihood of Fatal Cancer	Total Radiation Dose (rem)	Likelihood of Fatal Cancer
1. No Action	4.7	0.0019	0.12	6.0 x 10-5
2. Decentralization				
- No Exam	4.7	0.0019	0.12	6.0 x 10-5
- Limited Exam	4.7	0.0019	0.12	6.0 x 10-5
- Full Exam	4.7	0.0019	0.12	6.0 x 10-5
3. 1992/1993 Planning Basis	3.4	0.0014	1.0 x 10-5	5.0 x 10-9
4/5. Regionalization or Centralization				
- INEL	3.4	0.0014	1.0 x 10-5	5.0 x 10-9
- Hanford	3.4	0.0014	9.6 x 10-6	4.8 x 10-9
- Hanford/FMEF	3.4	0.0014	1.8 x 10-5	9.0 x 10-9
- S. River	3.4	0.0014	1.9 x 10-5	9.5 x 10-9
- S. River/Barnwell Plant	3.4	0.0014	1.5 x 10-4	7.5 x 10-8
- Nevada Test Site	3.4	0.0014	1.4 x 10-5	6.8 x 10-9
- Oak Ridge Reservation	3.4	0.0014	0.0040	2.0 x 10-6

values were determined based on a projected 40-year exposure at the location of the affected individual.

The radiological doses for workers represent the largest average dose from the particular facilities involved in an alternative. The average radiation dose for workers was selected by using the 1993 annual average shipyard or DOE site radiation exposure summaries (NNPP 1994b; NNPP 1994c). The radiological doses for maximum off-site individuals are the largest values calculated for a person located at the site boundary, closest to any facility involved under an alternative. These doses are based on the values for these individuals presented in Attachment F.

Employment impacts were determined from the nature of each alternative based on the experience at INEL. Table 3-7 presents a summary of potential socioeconomic impacts at each of the various sites for each of the alternatives evaluated in detail. The results indicate that as many as 500 long-term jobs and several hundred shorter-term construction jobs might be lost or gained at an affected site depending on the alternative selected.

Cost impacts were estimated from the nature of each alternative based on experience at INEL. **Table 3-8 presents a summary of the cost impacts for each of the alternatives evaluated in detail.** The summary provides the costs which would be incurred from construction as well as transportation and operation costs over the next 40 years. In all alternatives, there would be large costs, ranging up to $5.7 billion. For three of the alternatives involving continued operation of the ECF at INEL (1992/1993 Planning Basis, Regionalization at INEL, and Centralization at INEL), there would be only minor construction cost impact; however, the cost of continued ECF operation for an additional 40 years would be $2.6 billion. The cost values considered in preparing Table 3-8 include facility construction costs ranging from zero for alternatives involving no new facilities to a high of $800 million for those requiring a new facility with full examination capability. The transportation costs depend on destination and logistics and range from a low of $10 million to a high of $110 million. Fuel storage container costs range from a low of zero for those alternatives utilizing water pool storage to a high of $3.2 billion for shipping containers on railcars for the No Action alternative. Also included are operating costs over 40 years ranging up to $2.6 billion for the various alternatives, and Idaho ECF shutdown costs for those alternatives in which the present ECF is shut down.

Table 3-7. Summary of potential socioeconomic impacts.

	Impacts Associated with the Affected Site						
						Five NNPP Sites	
Alternative	INEL	Hanford	Savannah River	Nevada Test Site	ORR	Exam.	Store
1. No Action	Lose 500 jobs	No change	No change	No change	No change	No change	Add 50-100 jobs
2. Decentralization							
- No Exam	Lose 500 jobs	No change	No change	No change	No change	No change	Add 50-200 jobs
- Limited Exam	Lose 500 jobs	No change	No change	No change	No change	Add 60 jobs at Puget Sound	Add 50-200 jobs
- Full Exam	No change	No change	No change	No change	No change	No change	Add 50-200 jobs
3. 1992/1993 Planning Basis	No change	No change	No change	No change	No change	No change	No change
4/5. Regionalization or Centralization							
- INEL	No change	No change	No change	No change	No change	No change	No change
- Hanford	Lose 500 jobs	Gain 500 perm. jobs and some const. jobs	No change	No change	No change	No change	No change
- S. River	Lose 500 jobs	No change	Gain 500 perm. jobs and some const. jobs	No change	No change	No change	No change
- Nevada Test Site	Lose 500 jobs	No change	No change	Gain 500 perm. jobs and some const. jobs	No change	No change	No change
- Oak Ridge	Lose 500	No change	No change	No change			

Gain 500 perm. jobs and some const. jobs	No change	No change jobs
Reservation		

Table 3-8. Summary of cost impacts over 40 years.

	Cost ($ Billions)
No Action	3.6
Decentralization	
- No Exam	1.5 - 3.4*
- Limited Exam	1.8 - 3.7*
- Full Exam	3.8 - 5.7*
1992/1993 Planning Basis	2.6
Regionalization or Centralization	
- INEL	2.6
- Hanford	3.4
- Savannah River	3.5
- Nevada Test Site	3.5
- Oak Ridge Reservation	3.5

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* The cost varies under this alternative depending on the mode of storage. The most expensive options are those that use shipping containers for storage; the least expensive options are those that use immobile dry storage containers.

The largest cost ($3.8 to $5.7 billion) would be needed for new storage facilities or containers in addition to the ECF operational costs under the Decentralization - Full Examination alternative. Approximately $0.8 billion would be needed for the construction of new receipt, handling, and examination facilities at the alternative site if a Regionalization or Centralization alternative other than INEL were selected, thereby resulting in a cost of $3.5 billion over 40 years of operation. Somewhat less than $800 million would be needed for modifications to existing facilities if either of those options at Hanford or Savannah River were selected. Also, if the alternative involving the Barnwell Nuclear Fuel Plant at Savannah River were selected, additional funds would be needed to buy the Barnwell Plant as well as to modify it to meet the Program needs.

A hidden cost associated with the No Action alternative and two of the Decentralization alternatives is the loss or major reduction in the capability to examine naval spent nuclear fuel. Full examinations of naval spent nuclear fuel at the Expended Core Facility at INEL have been conducted since 1957. The examinations are a critical aspect of the Naval Nuclear Propulsion Program's ongoing advanced fuel research and development program. The information derived from the examinations at ECF provides engineering data on nuclear reactor environments, material behavior, and design performance. These data contribute to the Naval Nuclear Propulsion Program in two very significant ways.

First, this information is used to support the design of new reactors having extended lifetimes. For example, such examinations have contributed to extending the life of naval fuel from 2 years for the first reactor core in USS NAUTILUS to over 20 years for the latest nuclear-powered warships. The ultimate goal is to develop naval nuclear fuel that lasts the life of the ship; this would mean that no refuelings would be needed. Longer-lived fuel allows fewer refuelings, saves money in the costs of fuel and in the costs of work on ships, makes ships available for longer periods of service, and creates less spent nuclear fuel.

Second, information from these examinations has supported the operation of existing naval reactors by providing confirmation of proper design and allowing the fuel they contain to be used for the longest possible time.

Thus, the examinations of naval spent nuclear fuel are an integral part of the outstanding record of nuclear safety of the Naval Nuclear Propulsion Program. In over 4500 reactor-years of operation and more than 300 refuelings and defuelings of naval reactors, there has never been a nuclear reactor accident, criticality accident, or any release of radioactivity that has had a significant effect on the environment.

Preventing release of radioactivity from the fuel is extremely important to the safety of the

Navy personnel who operate the nuclear-powered warships since they must live aboard ship in close proximity to the reactor 24 hours a day.

While it is difficult to quantify the benefits of an outstanding safety record, increased core life yields an understandable economic gain. The gain is in a reduction in the number of reactor cores that must be procured and in the number of refuelings. Another gain is the increased on-line availability of nuclear-powered warships which is reflected in a decreased number of ships required. It is estimated that by achieving life-of-the-ship fuel and thus eliminating the need for any refuelings, a savings of approximately $5 billion will accrue for a force structure of less than 100 ships. The improvement in life from 2 years to 20 years has already avoided the need to perform 15 refuelings over the lifetime of each ship and reduced that to a single refueling.

3.8 TRANSITION PERIOD

A transition period would be required before any of the alternatives considered for naval spent nuclear fuel management could be fully implemented, except for those which would resume the historical practice of shipping naval spent nuclear fuel to the Expended Core Facility at INEL, followed by transfer to the Idaho Chemical Processing Plant for storage. This transition period would be needed to obtain the necessary additional funding and to build the necessary facilities and equipment.

For example, if the Record of Decision were to identify that the alternative of Centralization at Savannah River had been selected, a new Expended Core Facility would have to be funded and built at the Savannah River Site before shipments of naval spent nuclear fuel from shipyards could be directed to Savannah River. Similarly, if the No Action alternative were selected, additional shipping containers would have to be built since the available shipping containers for naval spent nuclear fuel will all be filled and waiting at the shipyards in June 1995.

Impacts of all alternatives evaluated for naval spent nuclear fuel management are low. Thus, the impacts of combinations of alternatives would also be low. The Environmental Impact Statement focuses on impacts at the time of full implementation in order to simplify the discussion and to calculate ceilings for the impacts. By doing so, it assures that impacts greater than those analyzed would not occur if one alternative were used for a small fraction of the 40-year period followed by a shift to another alternative for the remainder of the 40 years. This section discusses a transition period which is believed to represent a rapid but practical shift from the situation in June 1995 to full implementation of the ultimate alternative selected in the Record of Decision. This transition period would be about the same length for any alternative.

It is expected that the transition period would consist of 3 years of shipments of containers from the shipyards or prototypes to ECF at INEL beginning with issue of the Record of Decision in June 1995, and include approximately 80 total shipments. This would result in shipping to INEL the containers which had been filled and at the shipyards at that time. Many of the containers would then be emptied at ECF and returned to the shipyard where they would be reloaded. During this 3-year period, some of these containers would make a second trip to ECF at INEL for unloading after being returned to the shipyard. After these 3 years of shipments, no further shipments to INEL would be made, and the Expended Core Facility at INEL would be shut down. The shipping containers would then be refilled during the next 3 years, but kept at the shipyards or shipped to the location of the new examination or storage facilities.

If an alternative which does not continue storage of naval spent nuclear fuel at INEL were selected, procurement and contract actions to implement the course of action selected in the Record of

Decision would be initiated during these two 3-year periods. In accordance with the course of action selected in the Record of Decision, additional shipping containers or immobile dry storage casks would be built or construction of water pools would be initiated at shipyards or a new ECF at a DOE site would be started. It is assumed that these procurements or construction would have proceeded sufficiently that the shift to the selected option would be in full swing at this time.

3.9 PREFERRED ALTERNATIVE FOR NAVAL SPENT NUCLEAR FUEL

The specific elements discussed in each category of environmental impacts have been evaluated to determine the Navy's preferred alternative for managing naval spent nuclear fuel until means for permanent disposition become available. The costs and mission impacts have also been considered in selecting a preferred alternative.

Environmental Impacts: This Environmental Impact Statement (EIS) documents the potential environmental impacts of each alternative for naval spent nuclear fuel management. It considers environmental impacts under normal operations and hypothetical accident conditions on resources such as water quality and wetlands, air quality, land use, and public health. This EIS considers a range of potential accident initiators, such as natural hazards, transportation, and fuel handling.

The analyses demonstrate that the environmental impacts of implementing any of the alternatives would be very small for both normal operations and accident conditions. All alternatives would result in radiological impacts well below established DOE safety performance goals (SEN-35-91) of one tenth of one percent of the risk of fatal cancers from all sources (including natural causes). The impacts from any of the alternatives in non-radiological areas would also be extremely small. The analysis results do not provide a basis to distinguish among the alternatives in most of these areas.

Socioeconomic Impacts: The socioeconomic impact of implementing each of the alternatives would differ somewhat. The primary determinant of socioeconomic impact of the alternatives considered is employment. Total nation-wide employment levels would not vary significantly among alternatives for managing naval spent nuclear fuel, and therefore do not seem to provide a basis to distinguish among the alternatives. The maximum impact on existing employment levels would arise from alternatives requiring development of new naval spent nuclear fuel examination capability at a DOE facility other than INEL while terminating these activities at INEL. Resuming current practices of transporting naval spent nuclear fuel to the ECF at INEL for examination followed by transfer to the DOE for storage would result in the minimum disruption of employment levels.

Mission Impacts: Two important components of Naval Nuclear Propulsion Program operations are the safe management of naval spent nuclear fuel and support of the Navy's fleet of nuclear-powered warships. Based on the analyses in this EIS, all alternatives considered would allow safe storage of naval spent nuclear fuel until permanent disposition. However, some of the alternatives would not provide equal levels of Fleet support. Alternatives which limit or terminate naval spent nuclear fuel examination would severely impact ongoing research and development work. Naval spent nuclear fuel examination results are used to confirm the adequacy of design features, explore material performance, and confirm or adjust computer predictions of fuel performance. This information contributes to design and manufacturing of new naval reactor cores as well as understanding of operating ships. Each spent naval reactor core has its own unique manufacturing and operating history. Consequently, examination of each reactor core provides an opportunity to obtain new information relevant to reactor core performance. As discussed in Section 2.4.1 of this Appendix, the technical feedback obtained through this examination program is essential to extending the lifetime of naval reactor cores and assuring their operational safety. It is also important to understand that because of their long service lives, the first of the naval cores currently being used in LOS ANGELES Class submarines are just now being removed from operating reactors and becoming available for examination. The first cores from NIMITZ Class aircraft carriers and OHIO Class submarines have yet to be removed. These cores are the basis for all of the current fleet designs and are the starting point for new designs. Of the alternatives allowing full examination at the INEL, Hanford Site, Savannah River Site, Oak Ridge Reservation, or Nevada Test Site, examination at the INEL would have the smallest mission impact due to the presence of existing facilities and equipment for performing this work, and the presence of a highly skilled work force, all of which would need to be relocated or reassembled if a new examination site were selected.

Cost Impacts: There are large differences in the costs associated with all alternatives. Few additional costs would be associated with continuing the historic practice of shipping naval spent nuclear fuel to INEL for examination, followed by transfer to the DOE for storage pending permanent disposition. Alternatives involving developing facilities for storage of naval spent nuclear fuel at naval shipyards or developing examination facilities at a DOE site other than INEL would involve billions of dollars in additional costs, relative to historic practices, without any discernible improvement in safety or reduced environmental impacts.

Based on the analyses presented in this EIS, the Navy prefers an alternative which resumes the historic, technically sound, and safe practice of conducting refueling and defueling of nuclear-powered warships and prototypes as planned, transporting naval spent nuclear fuel to the Expended Core Facility at the INEL for full inspection and examination, and transferring naval spent nuclear fuel to the DOE for storage at that site. As summarized above, this preferred alternative avoids disruption of research and development work, minimizes disruption to existing employment levels and infrastructure, represents the lowest cost, and does not involve appreciable environmental impact. This preferred alternative can be accommodated under the 1992/1993 Planning Basis, Regionalization, or Centralization at Idaho.

3.10 REFERENCES

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4. AFFECTED ENVIRONMENT

4.1 NAVY AND PROTOTYPE SITES FOR NAVAL SPENT NUCLEAR

FUEL

4.1.1 PUGET SOUND NAVAL SHIPYARD: BREMERTON, WASHINGTON

4.1.1.1 Overview

The Puget Sound region lies in the northwest corner of Washington State as shown on Figure 4.1.1-1. The region is defined by the Olympic Mountain Range to the west and the Cascade Mountain Range to the east. The lowlands contrast dramatically with the mountains, with numerous channels, bays, and inlets on the inland sea that is Puget Sound. The Puget Sound Naval Shipyard is located inside the city limits of Bremerton, Washington at 47y 33' 30" north latitude and 122y 38' 8" west longitude. Bremerton is located in Kitsap County on the Sinclair Inlet 14 miles across Puget Sound west of Seattle and about 20 air miles northwest of Tacoma. Topography in the Bremerton area is characterized by rolling hills with an elevation range from sea level to +200 feet above mean sea level (msl) in West Bremerton and ranging up to y300 feet above msl in East Bremerton (area east of Port Washington Narrows). The predominant native vegetation in the area are douglas fir, cedar, and hemlock. Within a distance of 25 to 40 miles in a westerly direction from Bremerton, the Olympic Mountains rise to elevations of 4,000 to 7,000 feet. The higher peaks are covered with snow most of the year and there are several glaciers on Mount Olympus (elevation 7,954 feet). In an easterly direction and within a distance of 60 miles, the Cascade Range rises to average elevations of 5,000 to 7,000 feet with snowcapped peaks in excess of 10,000 feet.

Puget Sound Naval Shipyard is the largest activity of the Bremerton Naval Complex, which also includes the Fleet and Industrial Supply Center, Puget Sound and Naval Sea Systems Command Detachment, and Planning and Engineering for Repair/Alteration of Aircraft Carriers. Tenant activities include Naval Inactive Ship Maintenance Facility, Naval Reserve Center, and the Defense Printing Service. Figure 4.1.1-2 provides a shipyard vicinity map, and Figure 4.1.1-3 illustrates the Puget Sound Naval Shipyard.

4.1.1.2 Land Use

Kitsap County has historically been a semi-rural county. Roughly 80 to 85 percent of Kitsap County's total area is either forest, farmland, or undeveloped. The city of Bremerton and the surrounding vicinity is the largest population and economic center in the county and therefore has a lower percentage of agriculture and undeveloped land. Most development in Kitsap County is clustered around the commercial nodes of Bremerton, Port Orchard, Bainbridge Island, Kingston, Poulsbo, Silverdale, and Gorst, and near the shorelines.

The second largest land use category is residential, which is further broken down into low and medium density housing. More land area is devoted to single-family (low density) residential than to multi-family (medium density) development in this area.

Other land use delineations are parks and open space; commercial, which includes industry; mining; and much of the Navy buildings. The nearby land uses are typical of an area developed to a moderate intensity. The area contains residential, commercial, industrial, educational, and recreational facilities. The local waters support recreational and commercial activities including regularly scheduled ferry traffic.

Bremerton Naval Complex includes a total of approximately 1,347 acres consisting of uplands and submerged lands. Puget Sound Naval Shipyard has 327 acres of upland and is highly developed. Puget Sound Naval Shipyard also owns about 338 acres of submerged tidelands. The waterfront dry dock area is the high-security portion of the shipyard where most production takes place. It includes production shops, administration, and some public works and supply functions. The upland area of the shipyard is the military support area which provides services to military personnel, including housing, retail goods and services, recreation, counseling, dental care, and other support services.

The industrial support area in the southwestern portion of the shipyard includes several piers for homeported ships and inactive fleet, the power plant, warehouses, steel yard, public works shops, and parking.

Figure 4.1.1-1. Location of Puget Sound Naval Shipyard within Washington. Figure 4.1.1-2. Puget Sound Naval Shipyard vicinity map. Figure 4.1.1-3. Puget Sound Naval Shipyard site map.

4.1.1.3 Socioeconomics

Bremerton is the largest city within Kitsap County. The major population centers in Kitsap County other than Bremerton include Port Orchard, Poulsbo, Silverdale, Bainbridge Island, and Kingston. Kitsap County also has two reservations: the Port Madison Indian Reservation governed by the Suquamish Tribe, and the Port Gamble Indian Reservation governed by the S'Klallam Tribe.

The region surrounding the shipyard, within 50 miles, contains a population of approximately 3 million. Figure 4.1.1-4 provides a population distribution rose centered on the shipyard and covering a 50-mile radius. During 1989, Kitsap County ranked 7th as the most populous county in the state (Washington SESD 1990). According to the 1990 census, Kitsap County was the fifth fastest growing county in the state with a 28.9% growth rate for the decade for a total population of 189,731. The most recent estimate (April 1992), puts Kitsap's population at 205,600. The Kitsap Regional Planning Council projects the number of inhabitants to reach 280,985 by the year 2010, an increase of 48.10% over the 1990 figure.

Kitsap County's economy is largely affected by the federal government. Government is Kitsap County's largest employment sector, with the federal government having the greatest impact. As of 1993, Puget Sound Naval Shipyard was the largest employer in the county, employing about 10,200 civilian personnel. In 1990, the government sector's share of county employment was approximately 45 percent. The retail trade and services sectors are the county's next highest employers. Many of the service industries, such as the growing number of engineering and management firms, directly or indirectly support the military. By 1989, the services sector accounted for 21 percent of employment in the county and the retail trade sector accounted for 20.5 percent (Navy 1991a).

The majority of the labor force that would be employed at the shipyard for construction and operation of the naval spent nuclear fuel area would be expected to reside within about 20 miles from the shipyard. The calculated total population, labor force, and employment within this region for the base year (1995) are presented in Table 4.1.1-1. Projections of employment and population for the years beyond 1995 have not been presented because, as discussed in Section 5, the number of additional jobs that might be created at the shipyard under any alternative could be small.

Table 4.1.1-1. Regional employment factors at Puget Sound Naval Shipyard.

Regional Employment	Regional Labor Force	Regional Population
492,900	527,000	979,070

There are seven port districts in the county. The Port of Bremerton is the largest, with Bremerton and Port Orchard within its boundaries. The Port of Bremerton owns Bremerton National Airport, Olympic View Industrial Park, marinas in downtown Bremerton and Port Orchard, and the First Street Dock in Bremerton. Kitsap County is governed by a Board of Commissioners and is divided into three districts. Bremerton is split between the three districts. Regional planning is the responsibility of the Kitsap Regional Planning Council, and the Puget Sound Regional Planning Council, which is made up of elected officials from King, Kitsap, Pierce, and Snohomish counties and cities, and from the Indian tribal councils. Land use outside the shipyard is regulated by the city of Bremerton Comprehensive Plan and Zoning Ordinance. The Bremerton Area Council of Neighborhoods is made up of nine neighborhoods. The group was established to encourage citizen participation in Bremerton city planning (Navy 1991a).

Agencies responsible for environmental protection are the U.S. Army Corps of Engineers, U.S. Coast Guard, the Environmental Protection Agency (EPA), and the United States Fish and Wildlife Service (USFWS). The Washington State Department of Ecology and the city of Bremerton are responsible for the Coastal Zone Management Plan. The Department of Natural Resources has jurisdiction over marine lands management, and the Department of Fisheries and Department of Game protect wildlife resources. Washington's system of freeways, highways, and ferries is the responsibility of the Washington State Department of Transportation. Historic preservation programs for the state are administered by the Office of Archaeology and Historic Preservation.

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," requires federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs and activities on minority and low-income populations. An adverse environmental impact is a deleterious environmental impact determined to be unacceptable or above generally accepted norms.

A disproportionately high impact refers to an impact (or risk of an impact) in a low-income or minority community that significantly exceeds that on the larger community. Data available from the U. S. Census of 1990 have been used to develop information on the locations of minority and low-income populations within approximately 50 miles of the Puget Sound Naval Shipyard, consistent with the population data provided in Figure 4.1.1-4.

Figure 4.1.1-4. 50-mile population distribution around Puget Sound Naval Shipyard.

Figure 4.1.1-5 shows the locations of populations in which minority membership exceeds the average within the 50-mile radius by more than 20 percentage points and populations which have more than 50 percent minority members. These populations have been identified following an approach developed by the Environmental Protection Agency which, for purposes of environmental justice evaluation, defines minority communities as those which have percentages of minorities greater than the average in the region analyzed (EPA 1994).

Figure 4.1.1-6 shows the locations of populations which have more than 25 percent of their members living in poverty, reflecting a common definition of low-income communities (EPA 1993). The U. S. Census Bureau characterizes persons in poverty as those whose income is less than a "statistical poverty threshold." For the 1990 census, this threshold was based on a 1989 income of $12,500 per household.

4.1.1.4 Cultural Resources

Until the mid 1880s, Kitsap County was inhabited by several Native American tribes of the Salish language group who lived on the shores of Puget Sound. For about 100 years, the principal settlement of the Suquamish Tribe lay along the west shore of Agate Passage.

Congressional funding in 1891 led to the purchase of 190 acres of land on Sinclair Inlet for the construction of a dry dock, repair, and overhaul base for the U.S. Navy. This base was called the Puget Sound Naval Station.

No prehistoric archaeological sites have been identified at the Puget Sound Naval Shipyard. In addition, no submerged cultural resources have been recorded in the immediate vicinity of the shipyard. There are no Native American properties or ceremonial sites in the areas where spent nuclear fuel would be stored.

There is one National Historic Landmark and four National Registered Historic Districts within the shipyard. The east industrial portion of the shipyard was designated as a National Historic Landmark in 1992 as a part of the "World War II in the Pacific" group and contains buildings, piers, dry docks, and equipment that were used in World War II warship repairs. The four Historic Districts are: Officer's Row, Old Puget Sound Radio Station, Old Naval Hospital, and the Old Marine Reservation.

Figure 4.1.1-5. Minority population distribution within 50 miles of the Puget Sound Naval Shipyard.

Figure 4.1.1-6. Low-income population distribution within 50 miles of the Puget Sound Naval Shipyard.

4.1.1.5 Aesthetic and Scenic Resources

The Puget Sound region offers a striking contrast in terrain, with mountains; low, rolling hills; flat-topped ridges; and plateaus. These areas are separated by numerous channels, bays, inlets, lakes, and valleys. The shoreline along the county is characterized by moderate to steep irregular cliffs. The county has large areas of farmlands and forest.

The city of Bremerton and the Puget Sound Naval Shipyard are urbanized areas. The shipyard has an industrialized character along the shoreline, with parking areas, dry docks, warehouses, and ship traffic along Sinclair Inlet. The upland section of the shipyard contains housing, recreational facilities, and retail businesses. Chainlink fences mark the shipyard boundaries.

The area within the shipyard where the naval spent nuclear fuel would be stored has low visual sensitivity since the area is an industrial site.

4.1.1.6 Geology

4.1.1.6.1 General Geology.

The Kitsap Peninsula consists of several geological phenomena which have occurred over the past 60 million years. The upper layers of rock are generally underlain by hard, dense, fine-grained lava with an accumulation of several thousand feet (in most places) of marine sedimentary rocks above the lava flows. Uplifting of the Cascade and Olympic Mountain ranges caused the Kitsap Peninsula and other Puget Trough lowlands to become sites of deposition for sedimentary materials washed down from the surrounding ranges. More recently, glaciation, as well as erosion, have been responsible for carving the low, hilly, rolling topography of the area (Navy 1991a). The following geological discussion was obtained from "Site Inspection Report Puget Sound Naval Shipyard" (URS 1992).

Puget Sound Naval Shipyard is within the Puget Sound Lowland between the Olympic Mountains and the older Cascade Mountains to the east. Before the glaciation which occurred up to 1.7 to 2.2 million years ago, the Puget Sound Lowland probably contained a large river valley draining to the north and west into what is now the Strait of Juan de Fuca. Glaciation of the Puget Sound Lowland produced the arms and embayments of Puget Sound.

4.1.1.6.2 Geologic Resources.

Geological materials found in Puget Sound include hard, dense volcanic rock formed up to 63 to 65 million years ago, and fragmented sedimentary rocks, as well as unconsolidated sediments deposited by glaciers up to 1.7 to 2.2 million years ago. At least four separate glacial advances and accompanying periods between glaciers have been hypothesized for the Puget Sound Lowland. Soil layers deposited by glaciers are generally coarse sand and gravel, sand, silt from lakes, and low-permeability deposits left by glaciers. The soils from the periods between glaciers are generally fine-grained silts and sands deposited by rivers or lakes, interbedded with lenses of sand and gravel.

Most of the geologic material in Kitsap County is glacial deposits. The Kitsap Peninsula is the remnant of a plain formed from the debris deposited by glaciers. Volcanic bedrock outcrops near the south end of Sinclair Inlet and at Gold Mountain south and west of Bremerton. Sedimentary bedrock outcrops on the south end of Bainbridge Island and at the adjacent tip of the peninsula east of Bremerton.

Kitsap County has four basic soil types: soils underlain by cemented hard-packed subsoil or bedrock substrate; soils with permeable, distinctly stratified sublayers which are coarse and have good internal drainage; the organic soils represented by small, widely scattered areas of peat and muck; and soils having little or no agricultural or building potential. Typical landforms include rough mountainous land, steep broken land, coastal beaches, and tidal marshes.

The natural topography of the shipyard has been altered substantially from its original condition. Portions of the upland areas of the complex were cut to fill marshes and create level land. The resulting fill material was predominantly a silty, gravelly sand with occasional pockets of silts and clays. The surface of the filled areas is a solid layer of earth. The remaining areas of natural soils vary from dense deposits from glaciers to soft bay mud and peat. The upland soil is a stiff hard-packed clay soil with low permeability. (URS 1992)

There are no economic geologic resources at the shipyard.

4.1.1.6.3 Seismic and Volcanic Hazards.

Seismic risk related to structural damage may be represented in the United States by a relative scale of 0 through 4, with Zone 0 not expected to encounter damage and Zone 4 expected to encounter the greatest seismic risk. The Puget Sound Naval Shipyard is located in Zone 3. (UBC 1991) The Uniform Building Code seismic classification provides a means for a comparable assessment of the seismic hazard between the alternate sites.

If the Record of Decision identifies this site for the interim storage of naval spent fuel, then a detailed seismic evaluation would be conducted. More detailed information regarding the design basis considerations for storage of naval spent nuclear fuel at the shipyard is provided in Attachment D.

There have been approximately 200 earthquakes in the Pacific Northwest since 1840, most of which caused little or no damage. The most recent earthquakes of high magnitude in the region were near Olympia (approximately 40 miles from Bremerton) in 1949 (moment magnitude 7.1) and near Seattle in 1965 (moment magnitude 6.5). There has recently been speculation by some seismologists that earthquakes in the Puget Sound area might produce moment magnitudes as high as 8.2 to 8.8. On the other hand, some seismologists believe that earthquakes with moment magnitudes exceeding 7.0 are unlikely in this region. There is also some disagreement at present on the nature of fault movements that might occur in this area.

There is no known fault line within 3000 feet of the Bremerton Naval Complex; however, two known fault traces have been identified in Kitsap County. The Kingston-Bothell trace, in the northern portion of the county, and the Seattle-Bremerton trace, located a few miles north of Bremerton. There has been no known surface faulting in conjunction with earthquakes in the shipyard region.

Potential hazards from volcanism are minimal and limited to wind-borne volcanic ash. Both the distance of the shipyard from the Cascade vents and the configuration of the intervening topography exclude other volcanic hazards. Only ash from a "large" or "very large" eruption would reach the shipyard. The 1980 eruption of Mount St. Helens, Washington, approximately 120 miles south of the shipyard, resulted in a very slight coating of ash at the shipyard.

The potential hazard from large waves generated by volcanoes or earthquakes is minimal. The system of straits and inlets surrounding Puget Sound provides a natural barrier for the Puget Sound Area, which effectively dampens the propagation of distantly generated large waves. The risk of a local large wave generated by seismic events occurring that would affect the shipyard is small; however, seismologists have found evidence of a large, shallow focus earthquake near Seattle about 1300 years ago. This earthquake was most likely in excess of moment magnitude 7. In the event that a shallow focus earthquake such as this were to occur beneath Puget Sound, a tsunami could result which might cause flooding in the Puget Sound area. Because the largest earthquakes of record in the area are deep seated (more than 60 kilometers (37 miles)), and no major surface rupture is known to have occurred, the hazard of generation of a large wave by a local earthquake is minimal. The potential for landslide-generated waves is controlled by the geologic conditions; however, development of an earthquake-induced landslide of sufficient size to create a large wave is not expected.

A more detailed description of the regional geology and seismicity is documented in "Seismic Design Study - Water Pit Facility, Puget Sound Naval Shipyard, Bremerton, Washington" (Navy 1978).

4.1.1.7 Air Resources

4.1.1.7.1 Climate and Meteorology.

The general meteorological conditions of the Puget Sound area are typical of a marine climate, since the prevailing air currents at all elevations are from the Pacific Ocean. The relatively cool summers, mild winters, and wetness characteristic of a marine climate are enhanced by the presence of Puget Sound. The area tends toward damp, cloudy conditions much of the year. The Cascade Range to the east serves as a partial barrier to the temperature extremes of the continental climate of eastern Washington.

The normal annual precipitation near Bremerton is 38.33 inches. The rainy season extends from October to March and accounts for more than 75 percent of the yearly precipitation.

The mean annual temperature is 51.4yF. Normally, January is the month with the lowest average temperature of 39yF and July is the month with the highest average temperature of 64.5yF.

The average annual mean wind speed at the Seattle-Tacoma Airport is 9.0 miles per hour (mph), with a recorded maximum speed of 1-minute duration of 49 mph. Prevailing winds are from the southwest.

The mean annual relative humidity at the Seattle-Tacoma Airport at 4:00 a.m. (PST) is 83 percent, decreasing to 62 percent by 4:00 p.m. There is an average of 43.4 days per year that fog reduces visibility to 0.25 mile or less. The mean annual percent of possible sunshine is 46 percent. The month with the greatest mean percent of possible sunshine is July with 65 percent and the month with the least is December with 21 percent (Navy 1991a).

4.1.1.7.2 Air Quality.

An area can be designated by the Environmental Protection Agency as having air quality that is better than defined by the National Ambient Air Quality Standards (attainment) or as exceeding one or more of those standards (nonattainment for one or more pollutants). The Code of Federal Regulations, Title 40, Part 81, states that the Air Quality Control Region for the shipyard is better than national standards for total suspended particulate matter and SO2. The area has no specific classification for ozone, carbon monoxide, and NO2. The nearest Class I Area is the Olympic National Park, approximately 24 kilometers (15 miles) from the shipyard.

4.1.1.7.3 Existing Radiological Conditions.

Radiological facilities at all naval shipyards are designed to ensure that there are no uncontrolled discharges of radioactivity in airborne exhausts. Radiological controls are exercised to preclude exposure of working personnel to airborne radioactivity exceeding federal limits. Air exhausted from radiological work facilities is passed through high-efficiency particulate air filters and monitored during discharges. The annual airborne radioactivity emissions from the shipyards do not result in any measurable radiation exposure to the general public. Calculations of site radioactive airborne emissions for 1992 have been performed as described in Attachment F. These calculations have shown that emissions of radionuclides from each shipyard result in an effective dose equivalent of less than 0.1 mrem per year to any member of the general public.

4.1.1.8 Water Resources

4.1.1.8.1 Surface Water.

Numerous freshwater sources are found in Kitsap County, with numerous lakes dotting the county's landscape. Kitsap Lake, in west Bremerton, is one of the largest at 238 acres. Lakes and reservoirs are used for recreation and other public uses. Water for the city of Bremerton comes from surface and groundwater supplies.

Freshwaters in the Bremerton area are monitored by the Washington State Department of Ecology. Puget Sound Naval Shipyard has no important surface freshwaters.

Sinclair Inlet is located in Puget Sound. It is a narrow body of marine water approximately 1.1 miles wide at its widest point and approximately 3.5 miles long. A majority of the shoreline of Sinclair Inlet has been developed. The dominant feature is the shipyard, lying on the northern shore. The city of Port Orchard borders the southern shore. Localized areas of Sinclair Inlet contain toxic chemicals as a result of historic urban and industrial activities. Contaminants of concern include polychlorinated biphenyls (PCBs); polycyclic aromatic hydrocarbons (PAH); and toxic metals, such as chromium and mercury (PTI 1990). Fish taken from these localized areas show elevated concentrations of PCBs, mercury, and chromium.

Puget Sound tides are of the twice-daily, mixed type with two unequal highs and two unequal lows per day. Tides in the inlet are similar to those in Seattle, the primary reference station. The principal forces that produce currents in Sinclair Inlet are tidal. Generally, weak currents oscillate in direction moving water in and out of the inlet. The flushing capacity of the inlet is low due to low freshwater input (Navy 1991a).

Based on Flood Insurance Rate Map (FIRM) COMMUNITY-PANEL No. 530093 0015 and topographical maps, the Puget Sound Naval Shipyard is not in the 100 or 500 year floodplain.

4.1.1.8.2 Groundwater.

Groundwater is generally found within 100 feet of the ground surface in sand and gravel layers caused by material from receding glaciers. The rate of groundwater recharge in Kitsap County is estimated to be approximately 12 inches annually, equating to approximately 0.5 million gallons per day per square mile. The nature of the geology in the area is such that a well in almost any location can tap a number of aquifers at different depths. The quality of most groundwater near Bremerton is good. Groundwater is used for approximately 35 percent of the public water supply for Bremerton. Groundwater at Puget Sound Naval Shipyard is poor due to salinity caused by intrusion from Sinclair Inlet. (Navy 1991a).

4.1.1.8.3 Existing Radiological Conditions.

The normal activities associated with current naval nuclear operations at all naval shipyards do not result in the intentional discharge of any radioactive liquid effluent. However, there were occasions, primarily in the early 1960's, when measurable levels of radioactivity were discharged with liquid effluent. In all cases, effluent releases were less than permitted under the then current limits imposed by state and federal agencies.

The United States Environmental Protection Agency Office of Radiation Programs has performed monitoring of the water, plant life, aquatic life, and sediment in the vicinity of Puget Sound Naval Shipyard. The purpose of the survey was to determine if operations related to U.S. Navy nuclear warship activities resulted in releases of radionuclides which could contribute to significant population exposure or contamination of the environment. "Radiological Surveys of Naval Facilities on Puget Sound" (Lloyd and Blanchard 1989) discusses the most recent Environmental Protection Agency monitoring data. Pertinent conclusions are as follows:

1. "A trace amount of cobalt-60 (0.04 pCi/g+/-0.01 pCi/g) was detected in one sediment sample at PSNS. All other radioactivity detected in the 80 sediment samples is attributed to naturally occurring radionuclides or fallout from past nuclear weapons tests and the Chernobyl reactor accident in 1986."
2. "Results of core sampling did not indicate any previous deposit of cobalt-60 in the sediment."

3. "Water samples contained no detectable levels of radioactivity other than those occurring naturally."
4. "External gamma-ray measurements did not detect any increased radiation exposure to the public above natural background levels."
5. "Based on the current radiological surveys, shipyard and nuclear-powered warship operations have resulted in no increases in radioactivity that would result in major population exposure or contamination of the environment."

Environmental monitoring is conducted by the shipyard. The results of this monitoring program corroborate the Environmental Protection Agency's conclusions.

4.1.1.9 Ecological Resources

4.1.1.9.1 Terrestrial Ecology.

Vegetation and wildlife on Puget Sound Naval Shipyard are limited to "open spaces," noncontiguous, undeveloped areas which comprise approximately 46 acres of the entire Bremerton Naval Complex (Navy 1991a). Most of these areas have been previously disturbed and are currently landscaped with native and ornamental trees and shrubs.

Tree species include Douglas fir (Pseudotsuga menziesii), vine maple (Acer circinatum), big leaf maple (Acer macrophyllum), western red cedar (Thuja plicata), madrone (Arbutus menziesii), and western hemlock (Tsuga heterophylla). There are various types of thick underbrush present such as salal (Gaultheria shallon), sword fern (Polystichum sp.), Oregon grape (Berberis nervosa), and rhododendron (Rhododendron spp.) (Navy 1986).

Because of its location on the Pacific flyway, Puget Sound exhibits a diverse avifauana from an influx of seasonal migrants. Many of the migrants, particularly waterfowl, remain and overwinter in the sound because of the mild climate, abundance of bays and coves, and the availability of food. Due to the extensive industrial nature of the shipyard, its resident bird community is characterized by "urban species." Resident bird species include Stellar's jay (Cyanocitta stelleri), starling (Sturnus vulgaris), flicker (Colaptes spp.), American crow (Corvus brachyrhynchos), black-capped chickadee (Parus atricapillus), goldfinch (Spinus tristis), pigeon (Columba fasciata), robin (Turdus migratorius), golden-crowned kinglet (Regulus satrapa), evening grosbeak (Hesperiphona vespertina), and ring-necked pheasant (Phasianus colchicus) (Navy 1986). In addition, numerous glaucous-winged gulls (Larus glaucescens) inhabit the waterfront areas.

Although abundant mammal populations originally existed in the Puget Sound area, the current populations of mammals at the shipyard are extremely limited. The only mammals currently reported at the shipyard are gray squirrels (Sciurus griseus), mice, and shrews (Navy 1990a).

With few exceptions, reptiles and amphibians are not particularly abundant in the Puget Sound area. The lack of suitable habitat restricts the population of reptiles and amphibians at the shipyard to garter snakes, salamanders, newts, and frogs (Navy 1990a).

No environmental concerns associated with vegetation or wildlife have been identified at the shipyard.

4.1.1.9.2 Wetlands.

There are no freshwater wetlands on the shipyard. There are no streams, rivers, ponds, or lakes located on the shipyard (Navy 1986). The majority of the shipyard is developed and covered with an impervious surface. The shipyard does own 338 acres of water area (deep-water tidal property) along the waterfront.

4.1.1.9.3 Aquatic Ecology.

Salt marsh and brackish marsh communities formerly existed along much of the shoreline of Puget Sound. For a number of years, these areas were perceived as swampy wastelands and thousands of acres were diked, drained, and reclaimed.

The original landform of the shipyard has been greatly altered to accommodate its continuing development. Projects have increased the usable land by filling in the marsh area in the northwest corner and by extending the shoreline with quaywalls and landfill. The shoreside of the shipyard consists primarily of riprap, concrete bulkheads, and old wooden piers. Marine vegetation along the shipyard shoreline consists primarily of sea lettuce (Ulva lactuca), rockweed (Fuchus distichus), and debris of algae that have been dislodged from their subtidal moorings and carried inshore. There are no waterfront areas at the shipyard that have clam beds, eelgrass, kelp beds, or similar habitat (Navy 1986).

Resident fish populations inhabiting the shipyard intertidal shoreline include sculpins (Cottidae), surf perch (Embiotocidae), and flatfish (Pleuronectidae). Migratory fish species include Pacific salmon (Oncorhynchus spp.), sea-run cutthroat trout (Oncorhynchus clarki), Pacific tomcod (Microgadus proximus), Pacific cod (Gadus macrocephalus), Pacific herring (Clupea harengus pallasii), rockfish (Sebastes spp.), and two or three species of migratory smelt (Osmeridae) (Navy 1986). There is near-shore migration of juvenile salmon and other fish species annually, from March 15 to June 15. Herring mill in the vicinity of the shipyard from January 20 through April 15 (Navy 1991a). No recreational or commercial fishing is allowed within the confines of the shipyard.

4.1.1.9.4 Endangered and Threatened Species.

As required under Section 7 of the Endangered Species Act of 1973, the responsible agency of a major federal action must conduct a biological assessment to identify any endangered or threatened species which are likely to be affected by such action. The United States Fish and Wildlife Service had previously provided a list of endangered and threatened species that may be in the Bremerton area (Navy 1991a). The list included one species, the bald eagle (Haliaeetus leucocephalus). Wintering bald eagles may occur in the Bremerton area from about October 31 through March 31.

Bald eagles are regularly seen along most of the inland waters of Puget Sound. Eagles are active during the day and feed on a variety of animals (preferring fish or waterfowl) and carrion. They nest and rest most often in conifers, choosing large, open-crowned trees near water (Navy 1991a). Eagles are capable of tolerating a certain amount of intrusion and change; however, they tend to seek privacy for rearing their young.

Although no eagles have been reported nesting on the shipyard, there are several active nests within 1 mile of the shipyard (Navy 1991a). Trees suitable for perching and roosting are found in the non-industrialized area at the shipyard, but not near the waterfront. Bald eagles may feed within Sinclair Inlet anywhere and at any time. It is not likely that eagles feed on fish near the shipyard on a regular basis because of the high level of human activity and the variability of fish populations. Eagles in this area feed primarily on seagulls and other birds (Navy 1991a).

Marine mammals are afforded full federal protection under the Marine Mammal Protection Act of 1972. Pinnipeds (seals and sea lions) and cetaceans (whales, dolphins, and porpoises) that regularly or occasionally are found in central Puget Sound include the Pacific harbor seal (Phoca vitulina), California sea lion (Zalophus californianus), killer whale (Ordinus orca), Dall porpoise (Phocoenoides dalli), and harbor porpoise (Phocoena phocoena) (Navy 1991a).

The National Marine Fisheries Service had previously provided a list of endangered and/or threatened species under its jurisdiction that may occur in Puget Sound waters in support of the "Final Programmatic Environmental Impact Statement Fast Combat Support Ship (AOE-6 Class) U.S. West Coast Homeporting Program" (Navy 1991a). The list included two endangered mammals, the gray whale (Eschrichtius robustus) and the humpback whale (Megaptera novaeangliae); one threatened mammal, the Steller sea lion (Eumetopias jubatus); and one endangered turtle, the leatherback sea turtle (Dermochelys coriacea).

None of the sensitive, threatened, or endangered species are represented in the aquatic life of the shipyard (Navy 1991a).

4.1.1.10 Noise

Puget Sound Naval Shipyard is an existing industrial-type environment characterized by noise from truck and auto traffic; ship loading cranes and related diesel-powered equipment; and continuously operating transmission lines for steam, fuel, water, and related compressors for those and other liquids. In addition, new construction of buildings, reconstruction and rehabilitation activities for streets, buildings, parking lots, and ships all contribute to an industrial environment. Primary noise sources are located along the naval shore support facilities (piers and associated land-side facilities) and are dampened to the residential areas by the hills adjacent to the industrial area.

4.1.1.11 Traffic and Transportation

Primary regional land access to the Seattle/Tacoma/Bremerton area is achieved via two interstate highways, I-90 and I-5. Major transportation corridors in Kitsap County are based upon a network of state routes. The county's municipalities and population centers are accessed by State Routes (SR) 104, 303, 304, 305, and 308. The major thoroughfare in south Kitsap County is SR 16, which runs south from Bremerton to Tacoma and connects with I-5 in Tacoma.

Bremerton's primary access routes include SR 3, which is a major north-south thoroughfare that travels through western Bremerton; SR 303, which originates within Bremerton as Warren

Avenue and continues through eastern Bremerton to Silverdale; SR 304, which travels through Bremerton as Callow Avenue, Burwell Street, and Washington Avenue; Kitsap Way, which turns into 6th Street within the city; 11th Street, which provides local east-west circulation; and Wycoff, Montgomery, and Naval avenues, which provide local north-south circulation. The proposed Gorst to Bremerton Connector is a road-widening project that will improve accessibility to downtown Bremerton from SR 3 and SR 16.

Kitsap Transit provides transportation service to various areas of Kitsap County including population centers, ferry docks, and other activity centers, through a Public Transit Benefit Authority. In addition, tours and charters are available locally through Cascade Trailways which also offers a twice daily scheduled run to Tacoma. Taxi service is also available throughout the Kitsap County area.

Bremerton National Airport, used for general aviation, is the largest of three airfields located in Kitsap County and is located near SR 3 south of Bremerton. The other two airfields in the county are Port Orchard Airport and Apex Airpark near Silverdale.

Two ferry systems provide services to the Bremerton area. The Washington State Ferry System provides numerous daily runs from Bremerton, Kingston, Bainbridge Island, and Southworth to the Seattle area. There is also a state ferry run in the northern part of the county connecting Kingston to Edmonds, Washington, north of Seattle. In addition to the cross sound service provided by the Washington State Ferry System, Horluck Transportation Company runs a passenger-only service connecting downtown Port Orchard to Bremerton.

Burlington Northern Railroad provides scheduled and on-demand freight rail service to a number of locations in the southern and central portions of Kitsap County. A Navy-owned spur line from Shelton, Washington, provides additional rail service to the shipyard and Bangor Naval Submarine Base.

Naval spent nuclear fuel has been removed from Navy nuclear-powered ships and transported to the Idaho National Engineering Laboratory Expended Core Facility (ECF) for examination and evaluation as a routine part of their operating cycle. Starting in 1962, the naval spent nuclear fuel originating at Pearl Harbor Naval Shipyard was transported by ocean vessel to Puget Sound Naval Shipyard for subsequent rail shipment to ECF. From 1962 to the present, a total of 20 naval spent nuclear fuel shipments have been made from Pearl Harbor Naval Shipyard to Puget Sound Naval Shipyard, then on to ECF. In 1966, Puget Sound Naval Shipyard began removing naval spent nuclear fuel from Navy nuclear-powered ships and transporting it by rail to ECF. From 1966 to the present, a total of 115 shipments of naval spent nuclear fuel originating at Puget Sound Naval Shipyard have been made to ECF. Attachment A provides a list of the spent nuclear fuel shipments made to date by year and by originating shipyard. Attachment A also contains detailed descriptions of the shipping containers used for naval spent nuclear fuel shipments from shipyards.

Puget Sound Naval Shipyard has 23 miles of railroad tracks, 8 piers, 4 mooring sites, and 6 large dry docks.

4.1.1.12 Occupational and Public Health and Safety

4.1.1.12.1 Occupational Radiological Health and Safety. The Navy has well established and

effective Occupational Safety, Health, and Occupational Medicine programs at all of its shipyards. In regard to radiological aspects of these programs, the Naval Nuclear Propulsion Program policy is to reduce to as low as reasonably achievable the external exposure to personnel from ionizing radiation associated with naval nuclear propulsion plants. These stringent controls on minimizing occupational radiation exposure have been successful. No civilian or military personnel at Navy sites have ever exceeded the federal accumulated radiation exposure limit which allows 5 rem exposure for each year of age beyond age 18. Since 1967, no person has exceeded the federal limit which allows up to 3 rem per quarter year and since 1980, no one has received more than 2 rem per year from radiation associated with naval nuclear propulsion plants. The average occupational exposure of each person monitored at all shipyards is 0.26 rem per year. The average lifetime accumulated radiation exposure from radiation associated with naval nuclear propulsion plants for all shipyard personnel who were monitored is 1.2 rem. (NNPP 1994a) This corresponds to the likelihood of a cancer fatality of 1 in 2083.

The Navy's policy on occupational exposure from internal radioactivity is to prevent radiation exposure to personnel from internal radioactivity. The limits invoked to achieve this objective are one-tenth of the levels allowed by federal regulations for radiation workers. As a result of this policy, no civilian or military personnel at shipyards have ever received more than one-tenth the federal annual occupational exposure limit from internal radiation exposure caused by radioactivity associated with naval nuclear propulsion plants.

For work operations involving the potential for spreading radioactive contamination, containments are used to prevent personnel contamination or generation of airborne radioactivity. The controls for contamination are so strict that precautions sometimes have had to be taken to prevent tracking contamination from fallout and natural sources into radiological areas because the contamination control limits used in these areas were well below the levels of fallout and natural contamination occurring outside in the general public areas. A basic requirement of contamination control is monitoring all personnel leaving any area where radioactive contamination could possibly occur. Workers are trained to survey themselves (i.e., frisk), and their performance is checked by radiological control personnel. Frisking of the entire body is required, normally using sensitive hand-held survey instruments. Major work facilities are equipped with portable monitors, which are used in lieu of hand-held friskers. These stringent controls to protect the workers and the public from contamination have proven effective in the past.

In 1991, researchers from Johns Hopkins University, Baltimore, Maryland, completed a very comprehensive epidemiological study of the health of workers at the six naval shipyards and two private shipyards that service the Navy's nuclear-powered ships (Matanoski 1991). This independent study evaluated a population of 70,730 civilian workers over a period from 1957, beginning with the first overhaul of the first nuclear-powered submarine, USS NAUTILUS, through 1981, to determine whether there was an excess risk of leukemia or other cancers associated with exposure to low levels of gamma radiation.

The Johns Hopkins study found no evidence to conclude that the health of people involved in work on U.S. naval nuclear-powered ships has been adversely affected by exposure to low levels of radiation incidental to this work. Additional studies are planned to investigate the observations and update the shipyard study with data beyond 1981.

The radiation exposure during normal operations at each shipyard for workers who have their radiation levels monitored is determined based on the annual radiation exposure of 0.26 mrem per worker for all shipyards based on Naval Nuclear Propulsion Program Report NT-94-2 (NNPP 1994a). The total number of shipyard personnel monitored for radiation exposure associated with the Naval Nuclear Propulsion Program has been about 164,000.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. The radiation exposure to transportation workers for all historical shipments is 16.6 person-rem, which statistically corresponds to 0.0066 cancer fatalities. The maximum exposed individual (MEI) is a transportation worker, since the workers are closer to the shipment for a longer time than any member of the general population.
Under the limiting assumption that the same worker is associated with every shipment for the entire historical period, this person would receive a total exposure of 7.5 rem over the approximately 40-year period, or about 0.19 rem per year, which is within DOE standards for occupationally exposed individuals. The radiation exposures to workers correspond to much less than one incident cancer, which means that it is unlikely that there have been any past health impacts due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.1.12.2 Occupational Non-radiological Health and Safety.

The shipyard has an occupational health/preventive medicine unit and a branch clinic (industrial dispensary) which are run by Naval Hospital Bremerton. Personnel may also be taken to Harrison Memorial Hospital as needed.

The shipyard maintains two fire stations with approximately 50 personnel. The shipyard has a fire department that is fully equipped for structural and industrial firefighting and hazardous material spill response.

The shipyard has a security force of approximately 177 personnel providing law enforcement services, emergency services, security clearances, and parking and traffic control for the Bremerton Naval Complex.

In the non-radiological Occupational Safety, Health, and Occupational Medicine area, the Navy complies with the Occupational Safety and Health Administration regulations. The Navy policy is to maintain a safe and healthful work environment at all naval facilities. Due to the varied nature of work at these facilities, there is a potential for certain employees to be exposed to physical and chemical hazards. These employees are routinely monitored during work and receive medical surveillance for physical hazards such as exposure to high noise levels or heat stress. In addition, employees are monitored for their exposure to chemical hazards such as organic solvents, lead, asbestos, etc., and where appropriate are placed into medical surveillance programs for these chemical hazards.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. Approximately 0.028 fatalities are estimated as a result of non-radiological sources (vehicle emissions) associated with all historical shipments of spent nuclear fuel. This number includes both the workers and the general public. Since this number is much less than one, it is unlikely that there has been any non-radiological health impact due to the historical shipment of naval spent nuclear fuel over the entire history of such shipments.

4.1.1.12.3 Public Radiological Health and Safety.

In order to quantify the exposures resulting from normal shipyard radiological releases to the general public, detailed analyses were performed based on very conservative estimates of radioisotopic releases since releases began. Attachment F provides detailed annual release values used in the analyses.

The GENII computer code (Napier et al. 1988) was used to calculate exposures to human beings due to the estimated radionuclide releases from normal operations at the shipyards.

A person on the shipyard boundary at the location where the largest exposures would be received was used as the hypothetical maximally exposed off-site individual (MOI) for postulated releases of radioactive material from stored fuel. The population data used to calculate population exposures were taken from 1990 census data provided by the U.S. Census Bureau. Meteorology data were obtained as described in Attachment F.

The hypothetical exposures calculated in Attachment F for the period 1995 through 2035 were adjusted from an annual basis (1995) to the historical basis by multiplying by 38 years and by a factor of 1.7 to take into consideration variations in the number of ships and operations.

The calculated accumulated exposures through 1995 to the general population within 50 miles of the site (about 3 million people) are 1.3 person-rem. To provide perspective, the exposures received due to natural radiation sources through 1995 are approximately 34 million person-rem, based on 0.3 rem per person per year.

The results of environmental monitoring as described in Naval Nuclear Propulsion Program Report NT-94-1 show that Naval Nuclear Propulsion Program activities had no distinguishable effect on normal background radiation levels at site perimeters (NNPP 1994b).

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. The radiation exposure to the general population for all historical shipments is 1.95 person-rem, which statistically corresponds to 0.00098 cancer fatalities.

All of the radiation exposures to the general population correspond to much less than one incident cancer, which means that it is unlikely that there has been any past health impact to the public due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.1.12.4 Public Non-radiological Health and Safety.

Kitsap County has two hospitals, Harrison Memorial Hospital in East Bremerton and the Naval Hospital Bremerton.

Fire protection in Kitsap County is administered by local fire departments and fire districts. The Bremerton Fire Department has three stations. Police protection services in Kitsap County are provided by the County Sheriff's Office, the city of Bremerton, and other local jurisdictions providing mutual aid.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. Approximately 0.028 fatalities are estimated as a result of non-radiological sources (vehicle emissions) associated with all historical shipments of spent nuclear fuel. This number includes both the workers and the general public. Since this number is much less than one, it is unlikely that there has been any non-radiological health impact to the public due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.1.13 Utilities and Energy

Public water systems supply the majority of Kitsap County's water requirements. Wells are the primary source of water for outlying areas. The Bremerton watershed, located in the Gold Mountain area, is the largest single source for the city of Bremerton. A dam on the Union River provides the water storage reservoir. Freshwater is received at the shipyard from the city of Bremerton public water supply. A saltwater system is used at the piers and dry docks for firefighting, flushing, and cooling of ship systems. Refer to Section 4.1.1.8 for further discussion of water resources.

The Bonneville Power Administration and the Puget Sound Power and Light Company provide electrical service to Kitsap County. Rates for electrical power are relatively low due to the close proximity of hydroelectric facilities. The shipyard steam plant provides emergency electrical service, as well as steam.

A limited industrial natural gas distribution system exists in the east end of the complex. A majority of the military support area in the west end of the shipyard has been converted to natural gas. Natural gas is used industrially, since most of the buildings are heated by steam. The forge shop, foundry, and pipe shops are the largest users of gas. The only natural gas space heating in the industrial area is in the foundry (Navy 1991a).

Shipyard freshwater usage is approximately 676 million gallons annually.

Electricity usage is about 247,000 megawatt hours annually.

4.1.1.14 Materials and Waste Management

All of Bremerton's sewage is treated by the Bremerton Wastewater Utility at the Charleston Water Treatment Plant, located at the intersection of State Routes 3 and 304. This plant was completed in 1985 to provide secondary treatment. Navy ships produce sewage which is transferred to the city of Bremerton's Water Treatment Plant. Berthed ships generally have on-board pumps to discharge their sewage into the piers' sewage lines. In some cases, portable pumps are utilized to lift and pressurize.

Most of the solid waste produced by the shipyard is hauled by a private contractor to the privately owned Olympic View landfill. Miscellaneous acid and alkaline cleaning solution (concentrated liquid) is collected, stored on base, and eventually shipped to hazardous waste treatment storage and disposal facilities. Solid and liquid chemical wastes are collected, characterized, packaged, and labeled at the shipyard, then turned over to a contractor for disposal. A facility at the Manchester Fuel Department provides for the collection and recycling of oily wastes, sludges, and bilge waters (Navy 1991a).

Solid radioactive waste materials are packaged in strong, tight containers, shielded as necessary, and shipped to burial sites licensed by the U.S. Nuclear Regulatory Commission or a State under agreement with the U.S. Nuclear Regulatory Commission. Shipyards and other shore facilities are not permitted to dispose of radioactive solid wastes by burial on their own sites. During 1992, approximately 851 cubic yards of routine low-level radioactive waste containing 59 curies were shipped from the shipyard for burial.

Waste which is both radioactive and chemically hazardous is regulated under both the Atomic Energy Act and the Resource Conservation and Recovery Act (RCRA) as "mixed waste." Within the Naval Nuclear Propulsion Program, concerted efforts are taken to avoid commingling radioactive and chemically hazardous substances so as to minimize the potential for generation of mixed waste. For example, these efforts include avoiding the use of acetone solvents, lead-based paints, lead shielding in disposal containers, and chemical paint removers. Radioactive wastes, including those containing chemically hazardous substances, are handled in accordance with long-standing Program radiological requirements. Such handling includes solidification to immobilize the radioactivity, separation of the radioactive and chemically hazardous substances, removal of liquids from solids, and other simple techniques. A determination is then made as to whether the resulting waste is hazardous. As a result of Program efforts to avoid the use of chemically hazardous substances in radiological work, Program activities typically generate only a few hundred cubic feet of mixed waste each year. This small amount of mixed waste, along with limited amounts of mixed waste from Program work conducted prior to 1987, will be stored pending the licensing of commercial treatment and disposal facilities.

Since the complex contains so much pavement, surface drainage is required. An extensive storm sewer system exists, which is separate from the sanitary sewer system. The storm sewer discharges runoff into Sinclair Inlet through 15 outfalls (Navy 1991a).

4.1.2 NORFOLK NAVAL SHIPYARD: PORTSMOUTH, VIRGINIA

4.1.2.1 Overview

Norfolk Naval Shipyard is located in the Tidewater region of Virginia as shown on Figure 4.1.2-1. The shipyard is contiguous with the city of Portsmouth at 36y 49' 5" north latitude and 76y 17' 38" west longitude. The shipyard consists of over 1,200 acres and includes over 500 administrative, industrial, and support structures and 4 miles of shoreline. Figure 4.1.2-2 provides a vicinity map, and Figure 4.1.2-3 provides the site map for the Norfolk Naval Shipyard. For information, Figures 4.1.2-4 and 4.1.2-5 show the location and vicinity of Newport News Shipbuilding. Six city areas are within 15 miles of the shipyard: Portsmouth, Chesapeake, Norfolk, Virginia Beach, Hampton and Newport News, and Suffolk. The cities of Portsmouth to the immediate west, Chesapeake to the south, and Norfolk to the north and east surround the shipyard. The land area of Norfolk is separated from the shipyard proper by the Southern Branch of the Elizabeth River to the east and by the confluence of the Southern, Eastern, and Western Branches of the Elizabeth River to the north.

4.1.2.2 Land Use

Over 95 percent of the land area within the boundaries of the shipyard is covered by structures or paved with concrete and asphalt. The shipyard is divided internally into a controlled industrial area and a non-industrial area. All of the piers, dry docks, and work facilities accomplishing naval nuclear propulsion plant work are within the controlled industrial area.

The surrounding six city areas are a mix of urban, suburban, light industrial, and rural areas with the land areas dissected by the numerous rivers, creeks, bays, and wetlands.

Portsmouth is predominantly urban and suburban. The two main industries are the shipyard and the Portsmouth Marine Terminals, which are cargo shipping terminals operated by Virginia International Terminals. There are few undeveloped tracts of land in Portsmouth.

Figure 4.1.2-1. Location of Norfolk Naval Shipyard within Virginia. Figure 4.1.2-2. Norfolk Naval Shipyard vicinity map. Figure 4.1.2-3. Norfolk Naval Shipyard site map. Figure 4.1.2-4. Location of Newport News Shipbuilding within Virginia. Figure 4.1.2-5. Newport News Shipbuilding vicinity map.

Norfolk is north and east of the shipyard and separated from the Portsmouth land mass by the Elizabeth River. Downtown Norfolk is about 2.5 miles north-northeast of the shipyard and is the financial, cultural, and educational hub of the Southside area. Norfolk is primarily urban and suburban with light industrial centers scattered throughout the city. The Norfolk waterfront has commercial shipyards, coal terminals, various piers for bulk cargo such as gypsum and phosphate, and the Norfolk Naval Base. Like Portsmouth, Norfolk has few undeveloped tracts of land.

The Chesapeake corporate limit adjoins the Norfolk corporate limit just south of the St. Helena Annex and the Portsmouth corporate limit mid-stream of the Southern Branch of the Elizabeth River due east of the shipyard. The majority of the shipyard industrial area is across the river from Chesapeake. The land area immediately along the riverfront is industrial, bulk cargo terminals, and manufacturing. Chesapeake is a mixture of suburban and rural areas. The Western Branch Area adjoins Portsmouth and is primarily suburban with large tracts of undeveloped land currently used for crops to the south and west. Greenbriar adjoins Norfolk and is the central commercial hub of Chesapeake. Great Bridge adjoins Virginia Beach and is primarily residential with commercial corridors and regional shopping areas. The southern part of Chesapeake partially contains the Great Dismal Swamp and is rural with isolated residential areas scattered throughout the region.

Virginia Beach is not contiguous with any shipyard property but is within 15 miles. Virginia Beach adjoins Norfolk and Chesapeake on their eastern borders and fronts the Atlantic Ocean from Cape Henry to the North Carolina state line. The area between the ocean front resort strip and the Norfolk city line has undergone explosive growth over the past 20 years. The area is primarily residential with several commercial corridors connecting various parts of the city. A so-called "Green Line" divides the southern agricultural rural area from the developed areas in the northern part of Virginia Beach. This line has moved south in steps over the years in response to increasing pressure for further development.

Hampton and Newport News are adjoining cities lying on a peninsula formed by the James and York rivers. Newport News Shipbuilding and port facilities for coal and containerized cargo are the major industries. Although within 15 miles, the peninsula cities have historically been isolated from the southside cities economically and demographically as well as politically. This is slowly changing with the opening of the bridge-tunnel connecting western Tidewater with the peninsula. Inclusion of the peninsula cities into the Regional Standard Metropolitan Statistical Area joined the regions demographically. Land use is primarily suburban with several major commercial corridors dissecting and connecting the two cities. A downtown area of Newport News sits at the tip of the peninsula separated from the James River waterfront by coal terminals and the Newport News Shipbuilding facilities. The limited agricultural land is being rapidly supplanted by expanding residential and commercial development.

Suffolk is the westernmost of the southside cities. Suffolk is predominantly rural and has substantial land area under cultivation with peanuts, soybeans, and produce vegetables being the major crops. Residential areas are scattered but are becoming more numerous as land in Portsmouth and the Western Branch Area of Chesapeake is developed.

4.1.2.3 Socioeconomics

The shipyard is centrally located in relation to the six city population centers that comprise the Tidewater region. At the time of the 1990 census, approximately 1.5 million persons resided within a 50-mile radius of the shipyard. The six-city metropolitan area houses most of this population. Figure 4.1.2-6 provides a population distribution rose showing the population density and population for principal centers within 50 miles of the shipyard. Population data are based on the 1990 census.

As of 1993, Norfolk Naval Shipyard employed approximately 8,500 civilian personnel. The number of military personnel at the shipyard is typically between 2,000 and 3,000 and can vary at times up to approximately 15,000.

The majority of the labor force that would be employed at the shipyard for construction and operation of the naval spent nuclear fuel area would be expected to reside within about 20 miles from the shipyard. The total calculated population, labor force, and employment within this region for the base year (1995) are presented in Table 4.1.2-1. Projections of employment and population for the years beyond 1995 have not been presented because, as discussed in Section 5, the number of additional jobs that might be created at the shipyard under any alternative could be small.

Figure 4.1.2-6. 50-mile population distribution around Norfolk Naval Shipyard.

Table 4.1.2-1. Regional employment factors at Norfolk Naval Shipyard.

Regional Employment	Regional Labor Force	Regional Population
498,000	533,000	1,138,400

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," requires federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs and activities on minority and low-income populations. An adverse environmental impact is a deleterious environmental impact determined to be unacceptable or above generally accepted norms. A disproportionately high impact refers to an impact (or risk of an impact) in a low-income or minority community that significantly exceeds that on the larger community. Data available from the U. S. Census of 1990 have been used to develop information on the locations of minority and low-income populations within approximately 50 miles of the Norfolk Naval Shipyard, consistent with the population data provided in Figure 4.1.2-6.

Figure 4.1.2-7 shows the locations of populations which have more than 50 percent minority members within the 50-mile radius. Minorities make up approximately 33 percent of the total population in this area. These populations have been identified following an approach developed by the Environmental Protection Agency which, for purposes of environmental justice evaluation, defines minority communities as those which have percentages of minorities greater than the average in the region analyzed (EPA 1994).

Figure 4.1.2-8 shows the locations of populations which have more than 25 percent of their members living in poverty, reflecting a common definition of low-income communities (EPA 1993). The U. S. Census Bureau characterizes persons in poverty as those whose income is less than a "statistical poverty threshold." For the 1990 census, this threshold was based on a 1989 income of $12,500 per household.

4.1.2.4 Cultural Resources

Founded November 1, 1767 under the British flag, the shipyard pre-dates the United States Navy Department by 30 years. The first drydocking in the western hemisphere occurred at the shipyard on June 17, 1833. Dry dock 1 is a National Historic Landmark. Over the years, the shipyard has been greatly expanded. Beginning in 1963, the yard was authorized to perform Naval Nuclear Propulsion Program work.

Figure 4.1.2-7. Minority population distribution within 50 miles of the Norfolk Naval Shipyard.

Figure 4.1.2-8. Low-income population distribution within 50 miles of the Norfolk Naval Shipyard.

The Naval Shipyard Museum located at the foot of High Street in downtown Portsmouth contains many historical photographs and drawings, valuable artifacts, and archives of records tracing the 226-year history of the shipyard and its close ties to the city of Portsmouth. This museum is open to the public and to researchers.

No prehistoric archaeological sites have been identified at the Norfolk Naval Shipyard. In addition, no submerged cultural resources have been recorded in the immediate vicinity of the shipyard. There are no Native American properties or ceremonial sites in the areas where spent nuclear fuel would be stored. In the area where naval spent nuclear fuel would be stored, there are no historic sites that are potentially eligible or listed on the National Register of Historic Places (NPS 1991). Due to the historic nature of the shipyard, there might be areas of archaeological interest. In the past, artifacts from the early shipbuilding era have been uncovered during construction excavation.

4.1.2.5 Aesthetic and Scenic Resources

The lower Chesapeake Bay - Hampton Roads region is a flat coastal plain with minimal topographic relief. The numerous bays, rivers, and creeks that dissect the region provide access to various wetlands consisting of saltwater marshes, bogs, and swamps. The unique ecology of these wetlands provides habitat for numerous indigenous and migratory species of aquatic and avian wildlife. Area beaches fronting the Atlantic Ocean from Cape Henry southward and along the Chesapeake Bay westward from Cape Henry provide both scenic and recreational opportunities to area residents and visitors.

The shipyard is centrally located in a highly developed urban area and has an industrialized character. The area within the shipyard where the naval spent nuclear fuel would be stored has low visual sensitivity since the area is an industrial site. The original character of the area has been extensively modified in the 300 years that western man has occupied the area.

4.1.2.6 Geology

4.1.2.6.1 General Geology (Coch 1971).

The coastal plain is characterized by a series of marine transgressions with extended periods of non-marine erosion and deposition of river sediment. From the surface down to a depth of about 120 feet, the most recent sediments of the Columbia Group occur. Underlying the Columbia Group is the Yorktown Formation (deposits of fine silt, sand, and shells), which, at the location of the shipyard, is about 100 feet thick. The Calvert Formation, with a thickness of about 345 feet, underlays the Yorktown Formation.

The Calvert Formation consists of usually consolidated greenish-brown clays, silty clays, and silicon-based clays over a basic layer of coarse sand. The Calvert clays form an impermeable hard-packed barrier which limits the vertical migration of shallow groundwater. This barrier also isolates the Columbia and Yorktown regional aquifers from deeper lying aquifers contained in permeable formations underlying the Calvert. Extensive studies of the Coastal Plain of Virginia sponsored by the Virginia Division of Mineral Resources have been conducted and published in various bulletins and reports (Teifke and Onuschak 1973; Coch 1971).

4.1.2.6.2 Geologic Resources.

There are no unique or economic geological resources in the shipyard region. (Teifke and Onuschak 1973; Coch 1971)

4.1.2.6.3 Seismic and Volcanic Hazards.

Seismic risk related to structural damage may be represented in the United States by a relative scale of 0 through 4, with Zone 0 not expected to encounter damage and Zone 4 expected to encounter the greatest seismic risk. The Norfolk Naval Shipyard is located in Zone 1. (UBC 1991) No volcanic hazards exist. The Uniform Building Code seismic classification provides a means for a comparable assessment of the seismic hazard between the alternate sites. If the Record of Decision identifies this site for the interim storage of naval spent fuel, then a detailed seismic evaluation would be conducted. More detailed information regarding the design basis considerations for storage of naval spent nuclear fuel at the shipyard is presented in Attachment D.

4.1.2.7 Air Resources

4.1.2.7.1 Climate and Meteorology.

The Tidewater area is nearly surrounded by water with Chesapeake Bay to the north, Hampton Roads to the west, and the Atlantic Ocean to the east. The area contains numerous bays and is traversed by several rivers and creeks. The climate of the region is essentially marine. The land is level and low with an average elevation of 13 feet above sea level.

Based on the 1951 through 1980 period, the average first occurrence of 32 degrees Fahrenheit is November 17 and the average last occurrence is March 23. Temperatures of above 100 degrees are infrequent and below zero temperatures are almost nonexistent. The proximity to the surrounding water modifies the invading air masses. Summer winds are predominantly from the south and southwest, pulling large amounts of moisture up from the Gulf of Mexico. During the summer months, afternoon thunderstorms due to daytime heating of the near surface air are very common. Large areas of high pressure frequently stall just east of the southern coast. These "Bermuda Highs" can lead to extended periods of hot, humid weather with very little precipitation other than scattered thunderstorms. Thunderstorms occasionally spawn isolated tornadic activity throughout the region. Although locally destructive, the tornados move through the area rapidly along with storm centers.

Precipitation is distributed fairly evenly throughout the year and totals about 43 inches on the average. Snowfall is usually light and is frequently gone within 24 hours. Large accumulations do occur but are infrequent. July and August are generally the wettest months due to thunderstorms while November and December are the dryest. Average monthly precipitation is 3.5 inches. Spring weather can begin as early as March but more frequently occurs in April. This is a transitional period between winter and summer weather patterns. During the spring, summer-like days, rain, snow, and cold-humid weather can and frequently do occur during the same week. Mild weather in the fall usually extends through Thanksgiving.

Winter climate is primarily determined by the latitude of the upper level jet stream which steers eastwardly moving arctic air masses. Usually, winters are mild with alternating periods of cold and warm weather. Winter rains are frequent due to the frontal boundaries formed from low-pressure storm cells to the north and moisture-laden Gulf air moved into the area by a high-pressure area to the south. North to northeast winds predominate during the winter months. Northeast winds can affect the Atlantic Coast from the Carolinas northward. Strong northeast winds and heavy rains can cause localized flooding of low-lying areas. Since the Chesapeake Bay is shallow, a strong northeast wind can move large amounts of water from the north end of the bay southward. When this elevated water level is combined with a high tide, flooding occurs. Added to this is the heavy rainfall and poor drainage due to the low elevation. High tide levels 6 to 8 feet above normal are experienced during major northeast winds along with major beach erosion from Cape Henry to Cape Hatteras.

4.1.2.7.2 Air Quality.

An area can be designated by the Environmental Protection Agency as having air quality that is better than defined by the National Ambient Air Quality Standards (attainment) or as exceeding one or more of those standards (nonattainment for one or more pollutants). The Code of Federal Regulations, Title 40, Part 81, states that the Air Quality Control Region, in which the shipyard is located, is in marginal nonattainment for ozone and is better than national standards for total suspended particulate matter and SO2. The area has no specific classification for carbon monoxide and NO2. The nearest Class I Area is the Swanquarter National Wilderness Area, approximately 161 kilometers (100 miles) from the shipyard.

4.1.2.7.3 Existing Radiological Conditions.

Radiological facilities at all naval shipyards are designed to ensure that there are no uncontrolled discharges of radioactivity in airborne exhausts. Radiological controls are exercised to preclude exposure of working personnel to airborne radioactivity exceeding federal limits. Air exhausted from radiological work facilities is passed through high-efficiency particulate air filters and monitored during discharges. The annual airborne radioactivity emissions from the shipyards do not result in any measurable radiation exposure to the general public. Calculations of site radioactive airborne emissions for 1992 have been performed as described in Attachment F. These calculations have shown that emissions of radionuclides from each shipyard result in an effective dose equivalent of less than 0.1 mrem per year to any member of the general public.

4.1.2.8 Water Resources

4.1.2.8.1 Surface Water.

Hampton Roads is a relatively wide body of water formed by the confluence of the James, Elizabeth, and Nansemond Rivers. It connects on the east with the Chesapeake Bay. The natural depth of the main part of Hampton Roads ranges from 20 to 80 feet; however, the harbor shoals to less than 10 feet toward shore. Two channels are maintained at a depth of 40 feet by dredging. The currents in Hampton Roads are influenced considerably by the winds and have a velocity of 0.5 m/sec.

The Elizabeth River is the most downriver tributary of the James River. The Elizabeth River system is comprised of a main stem, running from Sewell's Point and Craney Island to Town and Pinner Points, plus four tributary arms: the Lafayette River and the Eastern, Western, and Southern Branches.

Deep navigation channels are maintained from Hampton Roads up the main stem and Southern Branch of the Elizabeth River. Project depths decrease from 45 feet at the mouth to 35 feet between the Norfolk Naval Shipyard and Newton Creek. The channels in the Eastern and Western Branch and Lafayette River are maintained at 25 feet, 14 feet, and 8 feet, respectively.

The Southern Branch of the Elizabeth River is an estuarine body of water in which tidal action brings about a mixing of salt and fresh water. This portion of the river is a slow-moving, heavily sediment-laden body of water. The movement of the water is affected by the narrowness of the channel and the influence of tidal action.

Located along the river banks and in the surrounding territory are extensive and important naval bases and docking facilities, pleasant exurbs and yacht clubs, dry docks and international shipping terminals, the commercial centers of Norfolk and Portsmouth, relatively quiet rural areas, and the Great Dismal Swamp.

Neither the Southern Branch of the Elizabeth River, nor the Hampton Roads Harbor, is fished commercially. Within these waterbodies, it has been established by the Virginia Department of Health that it shall be unlawful for any person, firm, or corporation to take shellfish from the condemned areas for any reason.

Norfolk Naval Shipyard is located on the Southern Branch of the Elizabeth River in a highly industrialized area of the city of Portsmouth, Virginia, 8 miles upstream from the confluence of the James and Elizabeth Rivers. The Southern Branch is a deep-water river which provides access to heavy industry (i.e., ship repairs, gas and oil distribution, etc.) in the vicinity of the shipyard. In addition, the Southern Branch is a major north-south part of the Army Corp of Engineers Intercoastal Waterway System.

The Southern Branch is brackish and is not a source of drinking water. The Southern Branch of the Elizabeth River-Naval Shipyard waterbody extends from Jones and Paradise Creeks to the Downtown Tunnel (Route 264). Shellfish condemnations impact 429 acres. This condemnation is due to historical sediment toxic contamination, and the potential for pollutants of fecal coliform bacteria (Virginia WCB 1992a). Sixteen industrial facilities discharge to the Southern Branch Elizabeth River main stem and tributaries. Surveys of finfish in the Elizabeth River (primarily in the Southern Branch) show obvious signs of stress and/or disease, especially among those species exposed to the contaminated bottom sediments. Many fish have external lesions, fin erosion, inflamed fins, and cataracts.

The bottom sediments of the Elizabeth River are highly contaminated with a variety of organic and inorganic compounds at several locations (Virginia WCB 1992a). The majority of the contamination problems occur in the highly industrialized Southern Branch. Of particular concern among the synthetic organic compounds found in the Southern Branch of the Elizabeth are polynuclear aromatic hydrocarbons (PAH's). They are long-lived, and many are mutagenic and carcinogenic. PAH's are found in a variety of sources including creosote, coal tar, coal pile runoff, fly and bottom ash from coal-fired boilers, roofing tar, asphalt oil, petroleum oil, bilge discharge, diesel soot, and wood stove soot. One source of this class of compounds in the Elizabeth River has been attributed to the wood-preserving facilities, which have been in operation along the Southern Branch since the early 1900's.

The James River-Hampton Roads waterbody encompasses the James River mainstem and tributaries from Old Point Comfort to Willoughby Spit (northern border) to the west side of Craney Island (eastern border), west to Barrel Point (southern border), and north to Boat Harbor, Hampton River, and Mill Creek. Shellfish condemnations impact 17,281 acres (Virginia WCB 1992a). This condemnation is due to historical toxic contamination, and the potential for fecal coliform bacteria pollution. This portion of the James River mainstem receives additional discharges from 14 facilities, at least half of which are seafood preparation waste discharges.

Surrounding the Nansemond River watershed are seven lakes (Lake Kilby, Lake Cahoon, Lake Meade, Speights Run Lake, Lake Prince, Lake Burnt Mills, and Western Branch Reservoir) which are used as public water supply sources for the surrounding cities. Lake Taylor, located in the city of Norfolk, is the closest lake and is approximately 7 miles from Norfolk Naval Shipyard. The other lakes are approximately 20 miles to the west of the shipyard.

The Flood Insurance Rate Map (FIRM COMMUNITY-PANEL No. 515529 0060 B) shows that most of the Norfolk Naval Shipyard, including the location considered for the interim storage of naval spent nuclear fuel, is in the 100-year floodplain. However, the location considered for naval spent nuclear fuel is not in a high-hazard area (as defined by Title 10, Part 1022 of The Code of Federal Regulations for floodplains) which is an area where frequent flooding occurs.

4.1.2.8.2 Groundwater.

Shallow groundwater underlies the whole region. Designated as the Columbia aquifer, it is composed primarily of sediments that were deposited up to 1.7 to 2.2 million years ago as channel fill and river or ocean terraces. The aquifer is composed of interbedded gravel, sand, silt, and clay and is unconfined throughout the region. The saturated thickness of the Columbia aquifer is about 80 feet in the Tidewater area.

A consolidated layer of silty clay underlies the water table and separates it from the Yorktown Formation. In general, water flow within the Columbia aquifer is from the topographic highs to topographic lows. This flow distribution is modified locally by the pumping of wells, dewatering of borrow pits, and by the upper contours of the Yorktown Formation. As a result, the depth of shallow wells can vary drastically in only a few hundred yards.

Underlying the Columbia aquifer are seven distinct aquifers that originate east of the Fall Line and progressively deepen as they proceed eastward. The names of the aquifers and their approximate depths at the location of the shipyard are shown in Table 4.1.2-2.

The material confining the individual aquifers thickens from west to east so that the vertical leakage between aquifers due to gravity or artesian pressure differentials decreases eastward. The Yorktown-Eastover aquifer is both confined and unconfined, depending on location, and consists of fine to coarse sand interbedded with clay, shell, and sandy clay. The formation thickness is about 100 feet in the vicinity of the shipyard. Where the aquifer is unconfined, it is a major source of recharge to both the water table aquifer and to underlying confined flow systems.

Table 4.1.2-2. Aquifers that underlie the Columbia aquifer.

Aquifer	Depth Below Sea Level (ft)
Yorktown - Eastover	Sea Level
Chickahominy - Piney Point	200
Aquia	400
Brightseat	500
Upper Potomac	750
Middle Potomac	900
Lower Potomac	>1500

Artesian pressure existing in the confined portions of the Yorktown aquifer causes an upward vertical leakage from the Yorktown aquifer into the water table aquifer. In the vicinity of the shipyard, the thickness of the confining layer is about 80 feet. The confining layer consists of blue-gray to green-gray clay interbedded with massive silty clay, fine sand, and chalky shell fragments.

The Yorktown aquifer is a major source of domestic, commercial, and light industrial water. Yields are reported to range from 20 to 250 gallons per minute. This aquifer is the usual source of drinking and domestic consumption water for those localities within the region not served by municipal water systems. The groundwater aquifers have been extensively monitored and results published in numerous papers, bulletins, and reports (Siudyla et al. 1981; USGS 1990). Groundwater quality is monitored by several state agencies and boards with annual reports submitted to the EPA and Congress (Virginia WCB 1992b).

Since the underlying layers slope downward from west to east, the flow of groundwater in the vicinity of the shipyard generally trends from west to east, with localized modifications as previously described.

Rivers and creeks bound the shipyard on the immediate east and south. The confluence of the Southern, Eastern, and Western Branches of the Elizabeth River occurs about 1.5 miles north of the shipyard. These stream beds are below sea level and thus intercept the water table aquifer.

Where an aquifer is interfaced with surface streams or impoundments, the net flow within the aquifer is toward the surface water. In the case of the shipyard, the water table aquifer is intercepted on three sides (N, E, S) by a surface stream. This confines any contaminant infiltrating into the aquifer to the area of and immediately adjacent to the shipyard property. With a net easterly flow due to gravity, any contaminant infiltrating from the shipyard area would percolate through the soil zone into the water table under the shipyard and be intercepted by bounding surface waters.

4.1.2.8.3 Existing Radiological Conditions.

The normal activities associated with current naval nuclear operations at all naval shipyards do not result in the intentional discharge of any radioactive liquid effluent. However, there were occasions, primarily in the early 1960's, when measurable levels of radioactivity were discharged with liquid effluent. In all cases, effluent releases were less than permitted under the then current limits imposed by state and federal agencies.

The United States Environmental Protection Agency Office of Radiation Programs has performed monitoring of the water, plant life, aquatic life, and sediment in the vicinity of Norfolk Naval Shipyard. The purpose of the survey was to determine if operations related to U.S. Navy nuclear warship activities resulted in releases of radionuclides which could contribute to significant population exposure or contamination of the environment. "Radiological Surveys of the Norfolk Naval Station, the Norfolk Naval Shipyard, and Newport News Shipbuilding" (Sensintaffar and Blanchard 1988) discusses the most recent Environmental Protection Agency monitoring data. Pertinent conclusions are as follows:

1. "The trace amounts of cobalt-60 measured in the harbor sediments are significantly less than observed during the 1968 survey and exist about 5 inches beneath the surface of the sediment, indicating that no detectable cobalt-60 has been deposited in the sediments since the 1968 survey.
2. In addition to cobalt-60, only radionuclides of natural origin plus trace amounts of cesium-137 from previous nuclear weapons testing were detected in any of the harbor sediment samples.
3. No tritium or gamma-ray emitters, other than those occurring naturally, were detected in harbor water, or samples of sediment, water, and vegetation collected from public areas.
4. Drinking water samples contained no detectable levels of radioactivity other than those occurring naturally.
5. The shoreline gamma-ray surveys failed to detect any elevated exposure levels except at one location where the levels are attributed to the naturally occurring radionuclides that exist in granite rock.
6. The levels and locations of radioactivity identified and the limited media in which it was found show that operations related to nuclear-powered warship activities resulted in no discernible adverse effects on public health or the environment."

Environmental monitoring is conducted by the shipyard. The results of this monitoring program corroborate the Environmental Protection Agency's conclusions.

4.1.2.9 Ecological Resources

4.1.2.9.1 Terrestrial Ecology.

The shipyard area is highly developed and its surface is about 95% covered with impervious materials. The few green areas are outside the controlled industrial area and have been extensively graded. Landscaping consists primarily of turf grasses and native trees. The oldest growth areas are in the vicinity of the Shipyard Commander's residence and Trophy Park. Appendix B of the "Land Management Plan for Norfolk Naval Shipyard" (NFEC 1991) lists those plants known to or likely to occur on the shipyard or its annexes.

The shipyard bird population consists of urban species commonly found in southeastern Virginia. These species include pigeons, jays, robins, finches, chickadees, starlings, flickers, blackbirds, grackles, cowbirds, chimney swifts, martins, mocking birds, cardinals, herons, egrets, terns, and several species of gulls. There are few mammals that inhabit the shipyard and their populations are limited. Squirrels and other rodents common to developed areas are observed.

The shipyard offers little refuge for reptiles and amphibians. Non-poisonous garter snakes and the occasional black snake are found in vegetated areas and in warehouse structures. Toads, newts, salamanders, and other semi-aquatic reptiles can be found in wet areas where suitable forage and habitat exists. Sightings are infrequent due to the dispersed habitat locations and the limited number of suitable sites.

The Tidewater area is part of the Mid-Atlantic flyway. Migratory species pass through the area or over-winter in the numerous bays, sounds, creeks, and wetlands that occur in the region. During migratory periods and over the winter, more than a hundred species of water fowl have been observed in the region. Since there is no suitable habitat or forage areas on the shipyard, the appearance of migrating species is rare.

4.1.2.9.2 Wetlands.

There are no freshwater wetlands on the main shipyard site where naval spent nuclear fuel would be stored. The majority of the shipyard is developed and covered with an impervious surface. National Wetlands Inventory Maps (DOI 1986) show a number of estuarine wetlands along the banks of Paradise, Blows, and St. Juliens Creeks. There are no remaining tidal wetlands along the western shoreline of the Southern Branch from its mouth to Paradise Creek (Silberhorn and Dewing 1989). The total wetland area along Paradise Creek is, according to this reference, about 422 acres.

Blows Creek wetlands occur along the Southern Branch and encompass about 2.54 acres. St. Juliens Creek tidal marshes are subdivided into eight locations and total about 52 acres (Silberhorn and Dewing 1991).

4.1.2.9.3 Aquatic Ecology.

The majority of the shipyard property is located on land that has been filled to raise its elevation above the level of the river. The shipyard shoreline consists of concrete bulkheads and finger piers built on concrete pilings. Wooden wharfs and quays have been replaced over the years with concrete structures. Marine vegetation along the shipyard waterfront is limited to red and green algae. As reported in Section 4.1.2.8.1, the marine life in the Southern Branch is limited due to the pollution in the river from sewage treatment plants and riverfront industries. There is no commercial fishing and only limited sport fishing in the Southern Branch. In the contiguous shipyard waters, there is no fishing due to a security buffer zone and because of the heavy traffic along the river.

Estuarine wetland ecology is principally vegetative and consists of Saltmarsh Cord grass and Reed grass. The abundance of Reed grass in these areas is indicative of disturbed wetlands that have been filled or are impacted by overloads of upland sediment.

Herring gulls, several species of terns, brown pelicans, egrets, herons, cormorants, and migratory bird species common along the Atlantic flyway take refuge in or feed on riverine or marshland environments and biota.

The waters adjoining the shipyard are frequently dredged to maintain the depth along the piers, at the entrance to dry docks, and in the turning basin. The periodic removal of silt and detritus limits the habitat of benthic organisms common in other parts of the lower bay and tributaries.

4.1.2.9.4 Endangered and Threatened Species.

There are no critical habitats as defined in 50CFR424.02 within the 15-mile tidal influence area. Several federally designated threatened (T) or endangered (E) species have been identified as existing in the vicinity. The exact locations of specific habitats could not be located; however, surveys of the area have not identified any habitat on shipyard property. The U.S. Fish and Wildlife Service lists the following species as endangered or threatened in the South Hampton Roads area from Suffolk eastward (DOI 1990).

1. Loggerhead turtle (T)
2. Bald eagle (E)
3. Peregrine falcon (E)
4. Piping plover (T)
5. Red-cockaded woodpecker (E)
6. Eastern cougar (E)
7. Dismal Swamp southeastern shrew (T)
8. Northeastern beach tiger beetle (T)

No state rare, threatened, or endangered species exist within the 15-mile tidal influence zone (Buhlmann and Ludwig 1992).

There are no marine mammals that are routinely found within the lower Chesapeake Bay or its tributaries. Manatees and Atlantic Bottlenose dolphins occasionally appear in the bay and Hampton Roads; however, their presence is transient. Stranding and grounding of pods of migratory whales and dolphins as well as carcasses of dead animals occasionally appear along Atlantic beaches from Virginia's Eastern Shore to the North Carolina Outer Banks but sightings of whales in the bay or near the ocean shore are rare.

Various oceanic turtles may nest along the sandy beaches surrounding the Chesapeake Bay and Outer Banks. The highly developed regions along the Elizabeth River do not provide suitable nesting sites for these marine reptiles.

4.1.2.10 Noise

Norfolk Naval Shipyard is an existing industrial-type environment characterized by noise from truck and auto traffic; yard cranes and related internal combustion engine powered equipment; and operating transmission lines for steam, air, and water along with associated pumps and compressors. The eastern shoreline of the Southern Branch contains private shipyards, manufacturing plants, and bulk material handling and storage terminals. These activities, along with Norfolk Naval Shipyard, add to the ambient noise levels of the river corridor.

Intervening structures and distance separate adjacent residential areas to the south and immediately west of the shipyard from the waterfront ship repair activities and thus attenuate the noise generated by those activities.

4.1.2.11 Traffic and Transportation

Within the city of Portsmouth, three main corridors, High Street, Portsmouth Boulevard, and George Washington Highway serve as access to suburban commercial and residential areas. The Downtown and Midtown tunnels link Portsmouth and Norfolk and join via connecting arteries the regional interstate highway network consisting of I-64, I-262, I-464, and I-664. I-64 crosses Hampton Roads while I-664 crosses the lower James River linking the southside cities to Newport News and Hampton on the peninsula. The bridge-tunnels allow the unimpeded flow of the largest commercial ships and warships through Hampton Roads.

Tidewater Regional Transit provides bus services throughout Portsmouth and Norfolk. Only limited public transportation is available in Chesapeake and Virginia Beach.

The Norfolk International Airport provides commercial scheduled passenger and cargo air service to major connecting hubs. Most private and general aviation not operating from Norfolk International operate from airports in Chesapeake, Suffolk, and Virginia Beach.

A passenger ferry across the Elizabeth River connects the Portsmouth downtown area with the Waterside Berths on the Norfolk side. This ferry service is primarily designed for tourist and recreational passengers rather than commuter service.

Norfolk Southern and CSX corporations operate extensive networks of rail transportation for freight and bulk cargo. Norfolk and Newport News are the nation's largest terminals for coal exports and, along with Portsmouth, have a large capacity for containerized and bulk cargos. Lines operated by CSX and Norfolk Southern subsidiaries serve the shipyard at the north and south ends, Southgate, and St. Juliens Creek annexes.

Naval spent nuclear fuel has been removed from Navy nuclear-powered ships and transported to the Idaho National Engineering Laboratory Expended Core Facility (ECF) for examination and evaluation as a routine part of their operating cycle. Naval spent nuclear fuel shipments from Norfolk Naval Shipyard to ECF were initiated in 1965. Since that time, 10 shipments of naval spent nuclear fuel originating at Norfolk Naval Shipyard have been made to ECF. The naval spent nuclear fuel was shipped by rail. Attachment A provides a list of these shipments made to date by year. Attachment A also contains detailed descriptions of the shipping containers used for naval spent nuclear fuel shipments from shipyards.

Norfolk Naval Shipyard has 30 miles of paved roads, 19 miles of railroad tracks, and dry docks.

4.1.2.12 Occupational and Public Health and Safety

4.1.2.12.1 Occupational Radiological Health and Safety. The Navy has well established and

effective Occupational Safety, Health, and Occupational Medicine programs at all of its shipyards. In regard to radiological aspects of these programs, the Naval Nuclear Propulsion Program policy is to reduce to as low as reasonably achievable the external exposure to personnel from ionizing radiation associated with naval nuclear propulsion plants. These stringent controls on minimizing occupational radiation exposure have been successful. No civilian or military personnel at Navy sites have ever exceeded the federal accumulated radiation exposure limit which allows 5 rem exposure for each year of age beyond age 18. Since 1967, no person has exceeded the federal limit which allows up to 3 rem per quarter year and since 1980, no one has received more than 2 rem per year from radiation associated with naval nuclear propulsion plants. The average occupational exposure of each person monitored at all shipyards is 0.26 rem per year. The average lifetime accumulated radiation exposure from radiation associated with naval nuclear propulsion plants for all shipyard personnel who were monitored is 1.2 rem. (NNPP 1994a) This corresponds to the likelihood of a cancer fatality of 1 in 2083.

The Navy's policy on occupational exposure from internal radioactivity is to prevent radiation exposure to personnel from internal radioactivity. The limits invoked to achieve this objective are one-tenth of the levels allowed by federal regulations for radiation workers. As a result of this policy, no civilian or military personnel at shipyards have ever received more than one-tenth the federal annual occupational exposure limit from internal radiation exposure caused by radioactivity associated with naval nuclear propulsion plants.

For work operations involving the potential for spreading radioactive contamination, containments are used to prevent personnel contamination or generation of airborne radioactivity. The controls for contamination are so strict that precautions sometimes have had to be taken to prevent tracking contamination from fallout and natural sources into radiological areas because the contamination control limits used in these areas were well below the levels of fallout and natural contamination occurring outside in the general public areas. A basic requirement of contamination control is monitoring all personnel leaving any area where radioactive contamination could possibly occur. Workers are trained to survey themselves (i.e., frisk), and their performance is checked by radiological control personnel. Frisking of the entire body is required, normally using sensitive hand-held survey instruments. Major work facilities are equipped with portable monitors, which are used in lieu of hand-held friskers. These stringent controls to protect the workers and the public from contamination have proven effective in the past.

In 1991, researchers from Johns Hopkins University, Baltimore, Maryland, completed a very comprehensive epidemiological study of the health of workers at the six naval shipyards and two private shipyards that service the Navy's nuclear-powered ships (Matanoski 1991). This independent study evaluated a population of 70,730 civilian workers over a period from 1957, beginning with the first overhaul of the first nuclear-powered submarine, USS NAUTILUS, through 1981, to determine whether there was an excess risk of leukemia or other cancers associated with exposure to low levels of gamma radiation.

The Johns Hopkins study found no evidence to conclude that the health of people involved in work on U.S. naval nuclear-powered ships has been adversely affected by exposure to low levels of radiation incidental to this work. Additional studies are planned to investigate the observations and update the shipyard study with data beyond 1981.

The radiation exposure during normal operations at each shipyard for workers who have their radiation levels monitored is determined based on the annual radiation exposure of 0.26 mrem per worker for all shipyards based on Naval Nuclear Propulsion Program Report NT-94-2 (NNPP 1994a). The total number of shipyard personnel monitored for radiation exposure associated with the Naval Nuclear Propulsion Program has been about 164,000.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. The radiation exposure to transportation workers for all historical shipments is 16.6 person-rem, which statistically corresponds to 0.0066 cancer fatalities. The maximum exposed individual (MEI) is a transportation worker, since the workers are closer to the shipment for a longer time than any member of the general population. Under the limiting assumption that the same worker is associated with every shipment for the entire historical period, this person would receive a total exposure of 7.5 rem over the approximately 40-year period, or about 0.19 rem per year, which is within DOE standards for occupationally exposed individuals. The radiation exposures to workers correspond to much less than one incident cancer, which means that it is unlikely that there have been any past health impacts due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.2.12.2 Occupational Non-radiological Health and Safety.

In the non-radiological Occupational Safety, Health, and Occupational Medicine area, the Navy complies with the Occupational Safety and Health Administration Regulations. The Navy policy is to maintain a safe and healthful work environment at all naval facilities. Due to the varied nature of work at these facilities, there is a potential for certain employees to be exposed to physical and chemical hazards. These employees are routinely monitored during work and receive medical surveillance for physical hazards such as exposure to high noise levels or heat stress. In addition, employees are monitored for their exposure to chemical hazards such as organic solvents, lead, asbestos, etc., and where appropriate are placed into medical surveillance programs for these chemical hazards.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. Approximately 0.028 fatalities are estimated as a result of non-radiological sources (vehicle emissions) associated with all historical shipments of spent nuclear fuel. This number includes both the workers and the general public. Since this number is much less than one, it is unlikely that there has been any non-radiological health impact due to the historical shipment of naval spent nuclear fuel over the entire history of such shipments.

The shipyard has an occupational health/preventive medicine unit and a branch clinic (industrial dispensary). Personnel may also be taken to Portsmouth Naval Hospital and Portsmouth General Hospital as needed.

The shipyard maintains two fire stations with approximately 60 personnel. The fire department is fully equipped for structural and industrial firefighting and hazardous material spill response.

The shipyard security force has approximately 100 personnel providing law enforcement services, emergency services, security clearances, and parking and traffic control for the Norfolk Naval Shipyard Complex.

Relative to social services, military personnel receive assistance through various programs at Portsmouth Naval Hospital and the Navy's Morale Welfare and Recreation Department.

4.1.2.12.3 Public Radiological Health and Safety.

In order to quantify the exposures resulting from normal shipyard radiological releases to the general public, detailed analyses were performed based on conservative estimates of radioisotopic releases since releases began. Attachment F provides detailed annual release values used in the analyses.

The GENII computer code (Napier et al. 1988) was used to calculate exposures to human beings due to the estimated radionuclide releases from normal operations at the shipyards.

A person on the shipyard boundary at the location where the largest exposures would be received was used as the hypothetical maximally exposed off-site individual (MOI) for postulated releases of radioactive material from stored fuel. The population data used to calculate population exposures were taken from 1990 census data provided by the U.S. Census Bureau. Meteorology data were obtained as described in Attachment F.

The hypothetical exposures calculated in Attachment F for the period 1995 through 2035 were adjusted from an annual basis (1995) to the historical basis by multiplying by 38 years and by a factor of 1.7 to take into consideration variations in the number of ships and operations.

The calculated accumulated exposures through 1995 to the general population within 50 miles of the site (about 1.5 million people) are 3.9 person-rem. To provide perspective, the exposures received due to natural radiation sources through 1995 are approximately 18 million person-rem, based on 0.3 rem per person per year.

The results of environmental monitoring as described in Naval Nuclear Propulsion Program Report NT-94-1 show that Naval Nuclear Propulsion Program activities had no distinguishable effect on normal background radiation levels at site perimeters (NNPP 1994b).

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. The radiation exposure to the general population for all historical shipments is 1.95 person-rem, which statistically corresponds to 0.00098 cancer fatalities.

All of the radiation exposures to the general population correspond to much less than one incident cancer, which means that it is unlikely that there has been any past health impact to the public due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.2.12.4 Public Non-radiological Health and Safety.

Portsmouth has three hospitals: Portsmouth General Hospital, Maryview Hospital, and Portsmouth Naval Hospital.

Fire protection in Portsmouth is administered by local fire departments and fire districts. The Portsmouth Fire Department has nine stations. Police protection services are provided by the city of Portsmouth.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. Approximately 0.028 fatalities are estimated as a result of non-radiological sources (vehicle emissions) associated with all historical shipments of spent nuclear fuel. This number includes both the workers and the general public. Since this number is much less than one, it is unlikely that there has been any non-radiological health impact to the public due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.2.13 Utilities and Energy

The shipyard purchases all of its water from the city of Portsmouth. Section 4.1.2.8.1 describes the sources of public water supplies for the region. A saltwater system is provided at berths and dry docks for cooling supplies to ship systems and for fire and flushing mains.

Shipyard and ship sewage effluents are discharged to the Hampton Roads sanitation district mains via the Portsmouth sewer system. Sewage treatment plants along the Southern Branch and lower James River receive and treat sewage from surrounding cities.

Electricity is purchased from Virginia Power Company transmission grids and is obtained from the Refuse Derived Fuel Plant located just south of the shipyard and operated by the Southeastern Public Service Authority. During periods of low demand, the Refuse Derived Fuel Plant sells electricity to Virginia Power. The Refuse Derived Fuel Plant also provides yard steam for operations and space heating.

Natural gas serves six buildings within the shipyard. Industrial uses include forging and tempering furnaces, various ovens and torches, laboratory burners, and cooking appliances in the cafeteria. This gas is purchased from Commonwealth Gas Company which serves the Portsmouth area.

Shipyard freshwater usage is approximately 823 million gallons annually.

Electricity usage is about 20,000 megawatt hours annually.

4.1.2.14 Materials and Waste Management

Solid waste generated by the shipyard is collected by a private contractor. Metals are segregated on-site in specially marked dumpsters to be recycled by the Defense Marketing and Reutilization Office. Solid burnable waste is transferred to the Southeastern Public Service Authority where it is either compacted into fuel blocks for use in the Refuse Derived Fuel Plant or disposed of at a regional landfill located in Suffolk. Once turned over, the Southeastern Public Service Authority determines the final disposition depending on the regional waste volume inventory at the fuel plant adjacent to the shipyard.

The Refuse Derived Fuel Plant provides electricity and steam to the shipyard and can provide power to the Virginia Power grid when excess capacity exists.

Liquid chemical wastes are collected, characterized, packaged, and labeled by the shipyard then turned over to a licensed contractor for disposal.

Solid radioactive waste materials are packaged in strong, tight containers, shielded as necessary, and shipped to burial sites licensed by the U.S. Nuclear Regulatory Commission or a State under agreement with the U.S. Nuclear Regulatory Commission. Shipyards and other shore facilities are not permitted to dispose of radioactive solid wastes by burial on their own sites. During 1992, approximately 1333 cubic yards of routine low-level radioactive waste containing 15 curies were shipped from the shipyard for burial.

Waste which is both radioactive and chemically hazardous is regulated under both the Atomic Energy Act and the Resource Conservation and Recovery Act (RCRA) as "mixed waste." Within the Naval Nuclear Propulsion Program, concerted efforts are taken to avoid commingling radioactive and chemically hazardous substances so as to minimize the potential for generation of mixed waste. For example, these efforts include avoiding the use of acetone solvents, lead-based paints, lead shielding in disposal containers, and chemical paint removers. Radioactive wastes, including those containing chemically hazardous substances, are handled in accordance with long-standing Program radiological requirements. Such handling includes solidification to immobilize the radioactivity, separation of the radioactive and chemically hazardous substances, removal of liquids from solids, and other simple techniques. A determination is then made as to whether the resulting waste is hazardous. As a result of Program efforts to avoid the use of chemically hazardous substances in radiological work, Program activities typically generate only a few hundred cubic feet of mixed waste each year. This small amount of mixed waste, along with limited amounts of mixed waste from Program work conducted prior to 1987, will be stored pending the licensing of commercial treatment and disposal facilities.

An extensive storm drain system exists on the shipyard to remove the runoff from precipitation. Outfalls empty into the Southern Branch, Paradise Creek, and St. Juliens Creek. About 100 outfalls serving the shipyard property have been mapped and located.

4.1.3 PORTSMOUTH NAVAL SHIPYARD: KITTERY, MAINE

4.1.3.1 Overview

Portsmouth Naval Shipyard is located in York County, in the southeast corner of Maine as shown on Figure 4.1.3-1. The Portsmouth Naval Shipyard is located in Portsmouth Harbor, the estuary of the Piscataqua River. This river flows between the states of Maine and New Hampshire. The shipyard is located on Seavey Island near the mouth of the river and is separated from Portsmouth, New Hampshire, by the main channel of the Piscataqua River and from Kittery, Maine by a back channel. Access to the shipyard is provided by two bridges from the Kittery shore. Figure

4.1.3-2 provides a shipyard site map.

Seavey Island has an area of 278 acres. The center reference point on the island is at 70y44'22" longitude and 43y04'56" latitude. The Portsmouth Harbor and its tributaries are used extensively for fishing, lobstering, and recreational boating. The port of Portsmouth is involved in importing salt and petroleum products, as well as exporting a variety of products, such as raw lumber.

4.1.3.2 Land Use

At the mouth of the Piscataqua River, several creeks and the river converge and mix with the Atlantic Ocean. The shipyard has been developed over time by filling in between five smaller islands and building a rock causeway to the approximately 5-acre undeveloped Clarks Island.

To the north, across the back channel, is the predominantly low-density residential community of Kittery, Maine. Kittery's land along the river and back channel is virtually all designated for residential use. The exceptions are two commercial areas located on Badgers Island and at the intersection of Routes 103 and 236 and several public use areas consisting of playgrounds and parks. The main commercial land use area is located along Route 1 and the Route 1 bypass. Most of Kittery's land further north is undeveloped due to natural constraints. The developable land is primarily designated for low-density residential use.

Figure 4.1.3-1. Location of Portsmouth Naval Shipyard within New Hampshire and Maine. Figure 4.1.3-2. Portsmouth Naval Shipyard site map.

Across the river, south of the shipyard, are the city of Portsmouth and the town of New Castle in the state of New Hampshire. Portsmouth's waterfront is nearly fully developed and has played an important role in the growth and prosperity of Portsmouth since it was settled as Strawberry Banke in 1623. Today there are areas of commercial, industrial, residential, and public/semi-public land use along the river.

Further inland, Portsmouth has large undeveloped land areas. Development on some of this land is constrained by wetlands and other natural factors; however, there still remains much acreage to accommodate future development.

Directly south of the shipyard is a large body of estuarine water containing several small islands. These islands are either undeveloped or have low-density housing.

The town of New Castle is predominantly developed with housing and is the location of a Coast Guard Station. Other land uses on the island town include commercial, public, and semi-public land.

4.1.3.3 Socioeconomics

Portsmouth Naval Shipyard is located in the small town of Kittery, Maine, a region of New England that consists predominantly of small rural towns.

Portsmouth, New Hampshire is the closest urban municipality to the shipyard. With a population of about 22,300, it is also the largest municipality in the area. Other larger municipalities within the area include Sanford and Biddeford in Maine and Rochester and Dover in New Hampshire. They have populations of approximately 20,500, 20,700, 26,600, and 25,000, respectively. Portland, Maine has a population of about 64,400. This major southern Maine urban center is located about 55 miles north of the shipyard. Also, the city of Boston, Massachusetts, with a population of about 574,300, is located approximately 50 miles south of the shipyard. Figure 4.1.3-3 provides a population distribution rose centered on the shipyard and covering a 50-mile radius.

Figure 4.1.3-3. 50-mile population distribution around Portsmouth Naval Shipyard.

The overall population of the Portsmouth region has grown through the 1980 to 1990 decade. On the Maine side of the Piscataqua River, the increase in population in York County from 1980 to 1990 was 24,848 which was a 17.8% increase. On the New Hampshire side of the river, the municipalities within Rockingham County gained in population through the 1980 to 1990 decade. There was a gain of 55,500 people or about a 29.2% increase.

Portsmouth Naval Shipyard is located within the "seacoast region" which is defined by seven job centers. Each center includes the smaller communities adjacent to them.

The seacoast region is made up of the Portsmouth, Exeter-Epping, Hampton, Dover-Somersworth, and Rochester centers in New Hampshire and the Kittery and Biddeford centers in Maine.

Historically, the economy of the seacoast region has been based on manufacturing. Textiles, shoes, and marine vessels were for many years the most important products of the region. Shipbuilding and ship repair, primarily at Portsmouth Naval Shipyard, have maintained a dominant role in the economy. Textiles and shoe manufacturing have declined over the past 30 years, but have been supplemented in part by plastics, electronics, and metals industries. The wages paid by these employers are low relative to those paid at the shipyard. On balance, the seacoast region has experienced consistent declines in manufacturing employment in recent years.

Non-manufacturing employment, especially in the trade and service sectors, is increasing. The Hampton, Portsmouth, Kittery, and Biddeford job centers have experienced economic growth as vacation resorts. Communities close to Massachusetts such as Hampton and Exeter-Epping, have grown as part of the Boston metropolitan area.

The city of Portsmouth is the seacoast region's trade and cultural center and a major distribution market for points in northern New England.

The generally healthy state of Portsmouth's economy is reflected by its excellent employment situation. As of July 1993, the unemployment rate was just 3.4% compared to the national average of 6.9%. The civilian labor force in the Portsmouth labor market area numbered 14,600 in July 1993.

The majority of the labor force that would be employed at the shipyard for construction and operation of the naval spent nuclear fuel area would be expected to reside within about 20 miles from the shipyard. The calculated total population, labor force, and employment within this region for the base year (1995) are presented in Table 4.1.3-1. Projections of employment and population for the years beyond 1995 have not been presented because, as discussed in Section 5, the number of additional jobs that might be created at the shipyard under any alternative could be small.

Table 4.1.3-1. Regional employment factors at Portsmouth Naval Shipyard.

Regional Employment	Regional Labor Force	Regional Population
115,230	121,550	258,900

Portsmouth has the distinction of being the only natural deep-water harbor between Boston and Portland, making it a major factor in New England seaborne commerce. Modern year-round port facilities, an established Foreign Trade Zone, and reliable container ship service are all available.

The chief commodities transported through the port are petroleum products which comprise over 90 percent of the marine commerce shipped. Large quantities of limestone (gypsum) and salt are also received. The chief products shipped out of Portsmouth are petroleum products and steel scrap. Commercial fishing in the area represents a multi-million dollar industry.

As of 1994, the region's largest employer, with approximately 4900 employees, was Portsmouth Naval Shipyard. The shipyard is the largest employer in the states of Maine and New Hampshire. The 1993 payroll amounted to $228 million.

Other contributing factors to the region's economic development include Pease Development Authority in Newington, the University of New Hampshire in Durham, and the New Hampshire Vocational/Technical College in Stratham.

The Kittery-York labor market area in York County had 86,165 people in the civilian labor force as of July 1993 and an unemployment rate of 2.3% for July 1993. The majority of the civilian labor force was employed in non-farm related jobs including manufacturing, transportation and utilities, wholesale and retail trade, finances, services, and government.

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," requires federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs and activities on minority and low-income populations. An adverse environmental impact is a deleterious environmental impact determined to be unacceptable or above generally accepted norms. A disproportionately high impact refers to an impact (or risk of an impact) in a low-income or minority community that significantly exceeds that on the larger community. Data available from the U. S. Census of 1990 have been used to develop information on the locations of minority and low-income populations within approximately 50 miles of the Portsmouth Naval Shipyard, consistent with the population data provided in Figure 4.1.3-3.

Figure 4.1.3-4 shows the locations of populations in which minority membership exceeds the average within the 50-mile radius by more than 20 percentage points and populations which have more than 50 percent minority members. These populations have been identified following an approach developed by the Environmental Protection Agency which, for purposes of environmental justice evaluation, defines minority communities as those which have percentages of minorities greater than the average in the region analyzed (EPA 1994).

Figure 4.1.3-5 shows the locations of populations which have more than 25 percent of their members living in poverty, reflecting a common definition of low-income communities (EPA 1993). The U. S. Census Bureau characterizes persons in poverty as those whose income is less than a "statistical poverty threshold." For the 1990 census, this threshold was based on a 1989 income of $12,500 per household.

4.1.3.4 Cultural Resources

The Portsmouth-Kittery area has been part of the country's history since its very beginning. Many structures and sites from the late seventeenth, eighteenth, and nineteenth centuries have survived within the framework of new development over the years, especially in the city of Portsmouth. Considered as a group, these preserved structures and sites constitute an aesthetic, cultural, and educational resource, and a heritage with increasing value to future generations in the Portsmouth-Kittery vicinity.

Figure 4.1.3-4. Minority population distribution within 50 miles of the Portsmouth Naval Shipyard. Figure 4.1.3-5. Low-income population distribution within 50 miles of the Portsmouth Naval Shipyard.

On November 17, 1977, the National Park Service, Department of the Interior, entered the Portsmouth Naval Shipyard Historic District on the National Register of Historic Places. The district includes 54 acres of land, and 59 buildings and structures. The shipyard qualified for the Historic Status because of its shipbuilding and repair function throughout the history of the United States, its unique industrial site, and its historical and architecturally interesting buildings. From the early colonial period to the present day, this shipbuilding and repair site served first, the British government, later, the revolutionary colonies, and finally, the United States through the eras of sail, steam, and atomic power. Portsmouth Naval Shipyard represents one of the country's earliest complete industrial operations. (Navy 1993a)

There are no known cultural resources in the area of the site where naval spent nuclear fuel would be stored. Due to the historic nature of the shipyard, there might be areas of archaeological interest. In the past, artifacts from the early shipbuilding era have been uncovered during construction excavation.

4.1.3.5 Aesthetic and Scenic Resources

The majority of the 303 acres (278 acres on the shipyard, 25 in Admiralty Village) that make up the Portsmouth Naval Shipyard is considered industrial use land. Although there are no exact figures on the breakdown of land classifications, it is estimated that over 75% of the area is covered by either buildings or pavement. The area within the shipyard where naval spent nuclear fuel would be stored has low visual sensitivity since the area is an industrial site. Improved grounds on the shipyard include the parade grounds, athletic fields and various lawns dispersed throughout. Semi-improved grounds include several small picnic areas on the shipyard, the Jamaica Island Family Recreation area, and the isolated grassy areas on the fringe of the streets and sidewalks. The major areas of unimproved grounds (includes all other unpaved acreage not classified as improved or semi-improved) include the two freshwater ponds and the small beach front on what was once Jamaica Island. Because Admiralty Village is a housing facility, what little open space remained after development was utilized for recreational purposes (e.g., tennis courts) or landscaped to enhance aesthetic value.

4.1.3.6 Geology

4.1.3.6.1 General Geology.

Portsmouth Naval Shipyard is located on Seavey Island in the Seaboard Lowland Section of the New England Province. This section has a low, undulating topography with low hills that are either bedrock with a light veneer of rocks or sediment left by glaciers, or marine clay.

The general area near Portsmouth Naval Shipyard is relatively flat, rising gradually to the foothills of the White Mountains and dissected by numerous streams and rivers that have, for example, carved gorges 20 to 100 feet deep in the granite hills of the Mount Agamenticus-Ogunquit area. What remains of the mountain range in the southern and western portions of the area are scattered and isolated, high, smooth, weathered rock hills.

The thickness of the overburden of loose materials varies from 0 to 200 feet over the region, with 80% of the area having less than 50 feet depth to bedrock. A predominant characteristic of the soil in the area is the presence of the groundwater table near or at the surface. (Navy 1984)

4.1.3.6.2 Geologic Resources.

The physical geography of the general area near the Portsmouth Naval Shipyard is characterized by bedrock prominences surrounded by and dissected by inlets and stream courses of the Piscataqua River. Seavey Island, itself a rock knob, is one of these prominent bedrock outcrops. The bedrock of Seavey Island is almost entirely the Kittery formation, a fine-grained, lime-silicate material consisting of chalky sandstone formed under heat and pressure, siltstone, and gray sandstone shale from approximately 400 million years ago. (Navy 1984)

There are no economic geologic resources at the shipyard.

4.1.3.6.3 Seismic and Volcanic Hazards.

Seismic risk related to structural damage may be represented in the United States by a relative scale of 0 through 4, with Zone 0 not expected to encounter damage and Zone 4 expected to encounter the greatest seismic risk. The shipyard is located in Zone 2A according to the "Uniform Building Code" (UBC 1991). No volcanic hazards exist. The Uniform Building Code seismic classification provides a means for a comparable assessment of the seismic hazard between the alternate sites. If the Record of Decision identifies this site for the interim storage of naval spent fuel, then a detailed seismic evaluation would be conducted.
More detailed information regarding the design basis considerations for storage of naval spent nuclear fuel at the shipyard is provided in Attachment D.

Numerous small faults are to be seen in all rock units of the region. Quantitatively, their abundance appears to be related to the brittleness of the rock containing them. Most involve displacement of a few inches or feet. Only one was deemed to be sufficiently important to show on the geologic map. This is the Portsmouth fault which forms the Rye-Kittery contact for approximately 9 miles. There are so few outcrops of the fault zone, and these are poor, that no attempt was made to calculate the fault displacement. It is not known if the fault continues across the Piscataqua River and into Southeastern Maine. (Navy 1993b)

4.1.3.7 Air Resources

4.1.3.7.1 Climate and Meteorology.

The overall climate in the Portsmouth region is characterized as variable. Weather conditions can change dramatically over short intervals. There are alternating frontal systems on a day-to-day basis, widely ranging daily and annual temperatures, and overall differences between the same seasons in different years.

Although this region is situated in the path of the prevailing westerly winds, the coastal area experiences a variety of air changes over the course of a year. These include: cold dry arctic air from the north, warm land air from the Gulf states, and cool, damp air from the Atlantic Ocean. It is the combinations of, or switches between, these conditions that generally cause the area's characteristic weather.

Weather conditions, especially temperature, in the Portsmouth general area are moderated by its maritime setting. The average daily temperature ranges from 80yF in July to 13yF in January and February. Temperatures can fluctuate outside this range, but they are not usually persistent.

Precipitation is fairly evenly distributed over the year, with 2.7 to 4.6 inches falling per month for a 42.6-inch annual total. On the average, there are about 130 days each year having more than a trace of precipitation. Most summer precipitation results from showers and, infrequently, thunderstorms. Winter precipitation is generally associated with stormy conditions caused by air masses moving up along the coast.

The cool Atlantic waters can produce extensive advection fog when warmer moist air is carried over the cool water. With any persistent eastern component in the wind direction, the fog that often lies just offshore during the summer can reach the coastline. This situation is increased during the summer by local sea breezes. All months of the year have a fairly consistent occurrence of fog. Localized and continuous fog was observed at the former Pease Air Force Base an average of 15% of the time and was dense enough to restrict visibility to 1.2 miles (2 kilometers) or less, about 35% of the time.

The predominant direction the wind blows from for the Portsmouth Harbor area is a combination of the western, southwestern, and southern sectors for a combined total of 36% of the time. Differences in wind characteristics occur on a seasonal basis with west-northwest winds dominating in the winter, and southwest-southeast winds increasing in frequency during spring and summer.

The wind speed averages 8.8 miles per hour in the Portsmouth Harbor area. Speeds greater than 40 miles per hour, however, can occur any time of the year. During the winter, increased wind speeds are normally caused by the northeast winds moving down the coast, while during the summer, high winds are more often associated with thunderstorms of squall lines moving through the area. (Navy 1991b)

4.1.3.7.2 Air Quality.

A Reasonably Available Control Technology analysis was conducted in response to Maine Department of Environmental Protection (DEP) regulations requiring Reasonably Available Control Technology for Volatile Organic Compound (VOC) emission sources, such as the Portsmouth Naval Shipyard, which are located in ozone nonattainment areas. The Reasonably Available Control Technology analysis was conducted for point and fugitive sources of VOC emissions at the shipyard.

The shipyard is a large industrial complex that emits VOC emissions from a variety of sources located throughout the site. Many of the sources of VOC are small and represent fugitive losses of emissions. VOC emissions from these operations are best controlled through the implementation of good housekeeping practices.

It has been determined that current VOC operations at the shipyard meet Reasonably Available Control Technology. Continuation of current practices will ensure that VOC emissions from the shipyard are maintained at or below Reasonably Available Control Technology levels. (Navy 1991b)

An area can be designated by the Environmental Protection Agency as having air quality that is better than defined by the National Ambient Air Quality Standards (attainment) or as exceeding one or more of those standards (nonattainment for one or more pollutants). The Code of Federal Regulations, Title 40, Part 81, states that the Air Quality Control Region for the shipyard is in moderate nonattainment for ozone and is better than national standards for total suspended particulate matter and SO2. The area has no specific classification for carbon monoxide and NO2. The nearest Class I Area to the shipyard is at the Presidential Range - Dry River Wilderness Area, approximately 120 kilometers (75 miles) from the shipyard.

4.1.3.7.3 Existing Radiological Conditions Radiological facilities at all naval shipyards are

designed to ensure that there are no uncontrolled discharges of radioactivity in airborne exhausts. Radiological controls are exercised to preclude exposure of working personnel to airborne radioactivity exceeding federal limits. Air exhausted from radiological work facilities is passed through high-efficiency particulate air filters and monitored during discharges. The annual airborne radioactivity emissions from the shipyards do not result in any measurable radiation exposure to the general public. Calculations of site radioactive airborne emissions for 1992 have been performed as described in Attachment F. These calculations have shown that emissions of radionuclides from each shipyard result in an effective dose equivalent of less than 0.1 mrem per year to any member of the general public.

4.1.3.8 Water Resources

4.1.3.8.1 Surface Water.

A large portion of York County's surface runoff from precipitation is drained by coastal basins reaching a short distance inland from the coast. The system of water drainage channels used by runoff waters, varying from very small brooks to larger rivers, generally are in a southeasterly direction towards the Atlantic Ocean, but tributaries naturally flow from all directions into the larger channels. The remainder of the area is drained by larger river drainage basins that reach further inland. The Saco River basin and the Piscataqua-Salmon Falls River basins are the largest drainage systems, the Mousam and Kennebunk Rivers being considerably smaller. In each of these drainage basins, surface water is held in swamps, ponds and lakes, both natural and man-made, and by dams for storage, water supply, and development of power.

The largest quantities of surface runoff occur during March, April, and May with the lowest occurring in August and September. On the average, runoff is approximately 22 inches of the 44 inches annual precipitation. The combination of spring rains and snow melt not only serve to greatly increase stream flow, but also tend to replenish groundwater supplies.

The Piscataqua River, formed by the confluence of the Cocheco River and the Salmon Falls River, flows southeasterly for 13 miles until it enters the ocean at Portsmouth Harbor. The entire 13 miles of the river is tidal. The river is one of the fastest flowing tidal waterways of any commercial port in the northeastern United States. Due to abrupt channel changes and the strengths of flood and ebb currents, hazardous cross-currents and eddies are found in the main channel passing north and east of Pierce and New Castle Island. The average current velocity at full strength in the main harbor varies from about 2.6 to 4.0 knots, whereas in the back channels, the velocity varies from less than 1 to 2 knots.

The tide at Portsmouth occurs twice daily. The average tidal range from Portsmouth Harbor is 8.4 feet. The average mean spring range is 9.7 feet and the average mean tide level is 4.2 feet.

New Hampshire and Maine have an agreement to maintain acceptable water quality in the Piscataqua River and both states regulate their effluent discharges into the river. The river is designated by the state of New Hampshire as a Class B segment and by the state of Maine as Class SB-1. New Hampshire Class B waters are acceptable for bathing, other recreational purposes, fish habitat, and public water supply after adequate treatment. Maine Class SB-1 waters are suitable for all clean water usages including water contact recreation, fishing, shellfish harvesting and propagation, and fish and wildlife habitat. (Navy 1984)

The Flood Insurance Rate Map (FIRM COMMUNITY-PANEL No. 230171 0008D) shows that the Portsmouth Naval Shipyard is not in a 100 or 500 year floodplain.

4.1.3.8.2 Groundwater.

Groundwater reserves constitute an important natural resource and are especially important to the more populated communities in the area. The majority of the public water supply in the area is taken from lakes and rivers, with groundwater providing the remainder of the requirements.

As much as 35% of the total area of York County is underlain by soils which are generally adapted to storage and yield of groundwater, but this figure is based only on surface data. In some localities, marine clays overlie deeper gravels and may represent excellent future sources. When favorable groundwater soils are measured to adequate depths, it is quite probable that the good groundwater yield areas will shrink to a few percent of the total land areas. (Navy 1984)

4.1.3.8.3 Existing Radiological Conditions.

The normal activities associated with current naval nuclear operations at all naval shipyards do not result in the intentional discharge of any radioactive liquid effluent. However, there were occasions, primarily in the early 1960's, when measurable levels of radioactivity were discharged with liquid effluent. In all cases, effluent releases were less than permitted under the then current limits imposed by state and federal agencies.

The United States Environmental Protection Agency Office of Radiation Programs has performed monitoring of the water, plant life, aquatic life, and sediment in the vicinity of Portsmouth Naval Shipyard. The purpose of the survey was to determine if operations related to U.S. Navy nuclear warship activities resulted in releases of radionuclides which could contribute to significant population exposure or contamination of the environment. "Radiological Survey of Portsmouth Naval Shipyard, Kittery, Maine and Environs" (Semler 1991) discusses the most recent Environmental Protection Agency monitoring data. Pertinent conclusions are as follows:

1. "No trace of Co-60 was detected in any samples at Portsmouth Naval Shipyard. All radioactivity detected in the 40 sediment samples is attributed to naturally occurring radionuclides or fallout from past nuclear weapons testing.
2. Results of core sampling did not indicate any previous deposit of Co-60 in the sediment.
3. The water samples contained no detectable levels of radioactivity.
4. All radioactivity detected in the biota samples is attributed to naturally occurring radionuclides or fallout.
5. External gamma ray measurements did not detect any increased radiation exposure to the public above natural background levels.
6. Based on the survey, it was concluded that current practices regarding nuclear-powered warship operations have resulted in no increases in radioactivity that would result in major exposure or contamination of the environment."

Environmental monitoring is conducted by the shipyard. The results of this monitoring program corroborate the Environmental Protection Agency's conclusions.

4.1.3.9 Ecological Resources

4.1.3.9.1 Terrestrial Ecology.

Portsmouth Naval Shipyard is an isolated land mass that has been highly developed. There is almost no remaining natural habitat in the shipyard area, with the major exception being Clarks Island and the surrounding estuary. Even these areas are not unaffected by activities on the shipyard and nearby industry.

The estuary around the shipyard could be classified as an intertidal river system which supports a subtidal estuary community. The shoreline is characterized by steep, rocky banks and low-lying marshlands. The shipyard mass would probably be classified as a rock outcrop ecosystem, characterized by sparse vegetation of low-lying shrubs and herbs with scattered trees. The community would be classified as an acidic shoreline outcrop.

The vegetation of the shipyard is made up primarily of trees, shrubs, and grasses that have been planted for landscaping purposes. No naturally occurring species remain at this time. Because Clarks Island has remained undeveloped, there is much greater diversity. It supports a variety of herbaceous and shrub species including rushes, skunk cabbage, jewelweed, spike grass, swamp azalea, bittersweet, witch hazel, and dogwood. Several lowland tree species are also growing on the island, including red maple, sycamore, willow, and poplar.

The fringe marshes along the shore of Admiralty Village and along portions of Clarks Island are dominated by two species, cord grass (Spartina alterniflora) and salt hay (Spartina patens). These perennial grasses are year-round producers of vital organic matter that is distributed to the detrital food chain or deposited in the marsh as part of the underlying peat marsh.

Another important plant species present within the Piscataqua River and abundant around the shipyard is Zostera marina, commonly called eel grass. This submerged marine flowering plant is vital to the health and productivity of the estuary. It provides habitat essential to the life cycle of species such as crabs, fin fish, geese, and ducks. Eel grass beds are also preferred nursery habitat for lobsters. Other valuable functions of eel grass beds include: sediment trapping, bottom stabilization, and water filtration. This filtration ability also causes eel grass beds to be susceptible to algal blooms resulting from excessive wastewater and fertilizer nutrients. Thus, eel grass is essential to the health of the estuary and can also serve as an indicator of unhealthy conditions.

The limited amount of vegetation and the highly industrialized nature of the shipyard area severely limit the availability of suitable habitat for most terrestrial species. There are some mammals on the shipyard, primarily those species that tend to live in close association with man, including: mice, squirrels, raccoons, and rabbits. There are white-tailed deer and moose in close vicinity of the shipyard. However, there are no known resident species of deer or moose on the shipyard. The Navy's 1993 "Natural Resources Management Plan for Portsmouth Naval Shipyard" contains a complete listing of all mammals and reptiles found in the southeastern Maine-New Hampshire region (Navy 1993b).

One notable ecological feature of the shipyard is its avian population. Bird species are most abundant in the region during the months of April and September, coinciding with the migratory seasons. The most common species in the area are the herring gull, American black duck, doublecrested commorant, great blue heron, and American crow. The most abundant winter migrant species are Canada geese, greater scaup, bufflehead, and common goldeye. Sea birds in general are the most abundant, and the year-round species include herring gulls and great black-backed gulls. The commom tern can also be found in large numbers during the late spring and summer. Osprey have also been known to frequent the area and there is one known nesting pair in the Great Bay Estuary vicinity. Appendix V. . of the Navy's Natural Resources Management Plan contains a complete list of bird species common to the coastal region (Navy 1993b).

Clarks Island serves as a safe haven for a multitude of birds. It is an optimum habitat for migratory species in that it has rocky shore, a small beach area, and an inland area of fairly dense wood and low-lying vegetation. It would not be unreasonable to expect that during the early spring and fall, Clarks Island would be utilized by a variety of songbird species along with the typical coastal species mentioned above. (Navy 1993b)

4.1.3.9.2 Wetlands.

There are a few isolated marine wetlands in the vicinity of the shipyard and a small freshwater wetland on the shipyard. There are two freshwater ponds on the southern portion of the base, which have been characterized as palustrine, unconsolidated bottom, and permanently flooded. There is a small area on the banks of the larger pond which is characterized as palustrine, scrub shrub, broadleaf deciduous wetland. There are also two very minute areas southwest of the freshwater ponds which have been characterized as palustrine emergent, persistent, seasonally flooded wetlands. Two areas of estuarine wetlands are noted. Along the northeast shoreline, they are classified as intertidal, unconsolidated shore, mud bottom, and regularly flooded. This same classification has been given to the northern shoreline of Clarks Island. Finally, on the western side of Clarks Island and on the southwestern corner of the shipyard, there are areas of estuarine intertidal aquatic bed, algal, regularly flooded wetlands. It should be noted that these determinations were based on stereoscopic analysis of aerial photographs and cannot be considered completely accurate without ground truthing. (Navy 1993b)

Because natural drainage systems are limited, the shipyard has developed an extensive storm water collection system and a drainage system to control flooding of the freshwater ponds. This collection system eventually drains into the Piscataqua River, as does surface runoff. (Navy 1993b)

4.1.3.9.3 Aquatic Ecology.

The waters surrounding the Portsmouth Naval Shipyard support a vast amount of marine life, from mammals to benthic organisms. Although the larger mammalian species, like whales and dolphin, are not common to the estuarine waters of the Piscataqua River, harbor seals can be seen throughout the Great Bay region in winter and spring. The estuary also supports a number of commercially and recreationally important fin fish including smelt, winter flounder, Atlantic silversides, alewives, and striped bass. A more complete list can be found in Appendix V. . of the Navy's Natural Resources Management Plan (Navy 1993b).

These fish species rely heavily on a healthy benthic invertebrate population for survival. Substrate type has a major impact on the number and variety of species that will be found in any particular area. The areas around the shipyard that have a rocky bottom will be populated by epibenthic organisms. Sandy or muddy bottoms can support both epibenthic and infaunal organisms. Some of the more common shellfish species include lobster, softshell clams, and blue muscles. A more detailed list of benthic infauna can be found in Appendix V. . of the Navy's Natural Resources Management Plan (Navy 1993b).

The freshwater ponds on the shipyard also serve as a source of aquatic species. There is a healthy benthic community within this ecosystem as well, including a variety of polychaete worms. There is an abundance of vegetation in and around the ponds, which provides habitat for freshwater fish. The most abundant fish species at this time is the smallmouth bass (Micropterus dolomieui), which were stocked at one time. (Navy 1993b)

4.1.3.9.4 Endangered and Threatened Species.

In the coastal area from Portland, Maine to Portsmouth, New Hampshire, the threatened or endangered species include the Piping Plover, Roseate Tern, Bald Eagle, Peregrine Falcon, Shortnose Sturgeon, and several species of whales and sea turtles.

Appendix V. . of the Navy's Natural Resources Management Plan (Navy 1993b) includes a list of the threatened and endangered species of southeastern Maine and New Hampshire. Both Maine and New Hampshire officials were consulted and have determined that there is no evidence to suggest that any threatened or endangered species reside on the Portsmouth Naval Shipyard. Marine mammals are afforded full federal protection under the Marine Mammal Protection Act of 1972 (Navy 1993b).

4.1.3.10 Noise

Portsmouth Naval Shipyard is an existing industrial-type environment characterized by noise from truck and auto traffic; ship loading cranes and related diesel-powered equipment; and continuously operating transmission lines for steam, fuel, water, and related compressors for those and other liquids. In addition, new construction of buildings, reconstruction and rehabilitation activities for streets, buildings, parking lots, and ships all contribute to a pervasively industrial environment.

4.1.3.11 Traffic and Transportation

The Kittery-Portsmouth area is very accessible to vehicular traffic due to the proximity of Interstate 95. The major cities of Boston, Massachusetts and Portland, Maine are approximately one hour away. U.S. Route 1, a primary road, runs parallel to I-95 in a north-south direction and provides good access to the local communities along the seacoast. Because of the shipyard's location on an island in the Piscataqua River, access is restricted to two federally owned bridges. The bridges provide access directly to the shipyard's northern boundary from residential streets in the town of Kittery. The majority of installation oriented traffic traverses five local secondary roadways:

Walker Avenue, Wenworth Street, and Shapleigh, Whipple, and Rogers Roads. Walker Avenue is the primary access route to Bridge 1 and Whipple Road provides direct access to Bridge 2. Most shipyard generated traffic is funneled from the two major highways, I-95 and U.S. Route 1, through the local roadways and over the bridges.

Daily rail service, freight only, is provided to Portsmouth Naval Shipyard by the Boston and Maine Railroad. The railroad connects Portsmouth with Manchester, New Hampshire; Portland, Maine; and Boston, Massachusetts. Rail passenger service is available via AMTRAK connecting to Boston.

Limited air service is provided at small airports at Eliot and Sanford, Maine, and Hampton and Rochester, New Hampshire. Pease Airport provides the opportunity for commuter flights to Logan Airport in Boston, Massachusetts and to other cities. In addition, Portsmouth is within one hour travel time by car from major airports at Boston, Massachusetts and Portland, Maine.

The Portsmouth Harbor, about 3 nautical miles from deep water of the Atlantic Ocean, is accessible year round via the Piscataqua River channel. The river channel is 35 feet deep below mean low water and 400 feet wide. There are about 500 vessel trips each way through the channel each year. About 150 of these trips involve ships with drafts greater than 18 feet, and more than 200 trips are made by tankers. A Coast Guard Station is located at New Castle near the harbor entrance. (Navy 1984)

Naval spent nuclear fuel has been removed from Navy nuclear-powered ships and transported to the Idaho National Engineering Laboratory Expended Core Facility (ECF) for examination and evaluation as a routine part of their operating cycle. Naval spent nuclear fuel shipments from Portsmouth Naval Shipyard to ECF were initiated in 1959. Since that time, 43 shipments of naval spent nuclear fuel originating at Portsmouth Naval Shipyard have been made to ECF. The naval spent nuclear fuel was shipped by rail. Attachment A provides a list of these shipments made to date by year. Attachment A also contains detailed descriptions of the shipping containers used for naval spent nuclear fuel shipments from shipyards.

4.1.3.12 Occupational and Public Health and Safety

4.1.3.12.1 Occupational Radiological Health and Safety. Portsmouth Naval Shipyard and the

Admiralty Village housing area are physically located in York County, Kittery, Maine on government-owned land. The U.S. Government provides its own police and fire protection on the shipyard, while Kittery provides police and fire protection for the Admiralty Village Housing Area. (Navy 1984)

The Navy has well established and effective Occupational Safety, Health, and Occupational Medicine programs at all of its shipyards. In regard to radiological aspects of these programs, the Naval Nuclear Propulsion Program policy is to reduce to as low as reasonably achievable the external exposure to personnel from ionizing radiation associated with naval nuclear propulsion plants. These stringent controls on minimizing occupational radiation exposure have been successful. No civilian or military personnel at Navy sites have ever exceeded the federal accumulated radiation exposure limit which allows 5 rem exposure for each year of age beyond age 18. Since 1967, no person has exceeded the federal limit which allows up to 3 rem per quarter year and since 1980, no one has received more than 2 rem per year from radiation associated with naval nuclear propulsion plants. The average occupational exposure of each person monitored at all shipyards is 0.26 rem per year. The average lifetime accumulated radiation exposure from radiation associated with naval nuclear propulsion plants for all shipyard personnel who were monitored is 1.2 rem. (NNPP 1994a) This corresponds to the likelihood of a cancer fatality of 1 in 2083.

The Navy's policy on occupational exposure from internal radioactivity is to prevent radiation exposure to personnel from internal radioactivity. The limits invoked to achieve this objective are one-tenth of the levels allowed by federal regulations for radiation workers. As a result of this policy, no civilian or military personnel at shipyards have ever received more than one-tenth the federal annual occupational exposure limit from internal radiation exposure caused by radioactivity associated with naval nuclear propulsion plants.

For work operations involving the potential for spreading radioactive contamination, containments are used to prevent personnel contamination or generation of airborne radioactivity. The controls for contamination are so strict that precautions sometimes have had to be taken to prevent tracking contamination from fallout and natural sources into radiological areas because the contamination control limits used in these areas were well below the levels of fallout and natural contamination occurring outside in the general public areas. A basic requirement of contamination control is monitoring all personnel leaving any area where radioactive contamination could possibly occur. Workers are trained to survey themselves (i.e., frisk), and their performance is checked by radiological control personnel. Frisking of the entire body is required, normally using sensitive hand-held survey instruments. Major work facilities are equipped with portable monitors, which are used in lieu of hand-held friskers. These stringent controls to protect the workers and the public from contamination have proven effective in the past.

In 1991, researchers from Johns Hopkins University, Baltimore, Maryland, completed a very comprehensive epidemiological study of the health of workers at the six naval shipyards and two private shipyards that service the Navy's nuclear-powered ships (Matanoski 1991). This independent study evaluated a population of 70,730 civilian workers over a period from 1957, beginning with the first overhaul of the first nuclear-powered submarine, USS NAUTILUS, through 1981, to determine whether there was an excess risk of leukemia or other cancers associated with exposure to low levels of gamma radiation.

The Johns Hopkins study found no evidence to conclude that the health of people involved in work on U.S. naval nuclear-powered ships has been adversely affected by exposure to low levels of radiation incidental to this work. Additional studies are planned to investigate the observations and update the shipyard study with data beyond 1981.

The radiation exposure during normal operations at each shipyard for workers who have their radiation levels monitored is determined based on the annual radiation exposure of 0.26 mrem per worker for all shipyards based on Naval Nuclear Propulsion Program Report NT-94-2 (NNPP 1994a). The total number of shipyard personnel monitored for radiation exposure associated with the Naval Nuclear Propulsion Program has been about 164,000.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. The radiation exposure to transportation workers for all historical shipments is 16.6 person-rem, which statistically corresponds to 0.0066 cancer fatalities. The maximum exposed individual (MEI) is a transportation worker, since the workers are closer to the shipment for a longer time than any member of the general population.
Under the limiting assumption that the same worker is associated with every shipment for the entire historical period, this person would receive a total exposure of 7.5 rem over the approximately 40-year period, or about 0.19 rem per year, which is within DOE standards for occupationally exposed individuals. The radiation exposures to workers correspond to much less than one incident cancer, which means that it is unlikely that there have been any past health impacts due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.3.12.2 Occupational Non-radiological Health and Safety.

In the non-radiological Occupational Safety, Health, and Occupational Medicine area, the Navy complies with the Occupational Safety and Health Administration Regulations. The Navy policy is to maintain a safe and healthful work environment at all Navy facilities. Due to the varied nature of work at these facilities, there is a potential for certain employees to be exposed to physical and chemical hazards.
These employees are routinely monitored during work and receive medical surveillance for physical hazards such as exposure to high noise levels or heat stress. In addition, employees are monitored for their exposure to chemical hazards such as organic solvents, lead, asbestos, etc., and where appropriate are placed into medical surveillance programs for these chemical hazards.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. Approximately 0.028 fatalities are estimated as a result of non-radiological sources (vehicle emissions) associated with all historical shipments of spent nuclear fuel. This number includes both the workers and the general public. Since this number is much less than one, it is unlikely that there has been any non-radiological health impact due to the historical shipment of naval spent nuclear fuel over the entire history of such shipments.

4.1.3.12.3 Public Radiological Health and Safety.

In order to quantify the exposures resulting from normal shipyard radiological releases to the general public, detailed analyses were performed based on very conservative estimates of radioisotopic releases since releases began. Attachment F provides detailed annual release values used in the analyses.

The GENII computer code (Napier et al. 1988) was used to calculate exposures to human beings due to the estimated radionuclide releases from normal operations at the shipyards.

A person on the shipyard boundary at the location where the largest exposures would be received was used as the hypothetical maximally exposed off-site individual (MOI) for postulated releases of radioactive material from stored fuel. The population data used to calculate population exposures were taken from 1990 census data provided by the U.S. Census Bureau. Meteorology data were obtained as described in Attachment F.

The hypothetical exposures calculated in Attachment F for the period 1995 through 2035 were adjusted from an annual basis (1995) to the historical basis by multiplying by 38 years and by a factor of 1.7 to take into consideration variations in the number of ships and operations.

The calculated accumulated exposures through 1995 to the general population within 50 miles of the site (about 2.4 million people) are 0.65 person-rem. To provide perspective, the exposures received due to natural radiation sources through 1995 are approximately 28 million person-rem, based on 0.3 rem per person per year.

The results of environmental monitoring as described in Naval Nuclear Propulsion Program Report NT-94-1 show that Naval Nuclear Propulsion Program activities had no distinguishable effect on normal background radiation levels at site perimeters (NNPP 1994b).

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. The radiation exposure to the general population for all historical shipments is 1.95 person-rem, which statistically corresponds to 0.00098 cancer fatalities.

All of the radiation exposures to the general population correspond to much less than one incident cancer, which means that it is unlikely that there has been any past health impacts to the public due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.3.12.4 Public Non-radiological Health and Safety.

The Naval Medical Clinic located on the shipyard is used by Navy personnel and dependents for their general medical care requirements. Medical problems that require treatment not available at the clinic are taken care of at hospitals located in York, Maine and Portsmouth, New Hampshire. (Navy 1984)

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. Approximately 0.028 fatalities are estimated as a result of non-radiological sources (vehicle emissions) associated with all historical shipments of spent nuclear fuel. This number includes both the workers and the general public. Since this number is much less than one, it is unlikely that there has been any non-radiological health impact to the public due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.3.13 Utilities and Energy

Portsmouth Naval Shipyard has its own Security, Fire, Public Works, and Supply departments.

Portsmouth Naval Shipyard obtains its electricity from Central Maine Power, but has a central power plant capable of producing all of the required steam and electricity. Potable water is furnished by the town of Kittery, Maine. (Navy 1984)

The 1993 electrical power usage at Portsmouth Naval Shipyard was 76,262 megawatt hours. The water usage at the shipyard was approximately 668 million gallons for 1993.

4.1.3.14 Materials and Waste Management

The shipyard's sewage is pumped to the town of Kittery's sewage treatment system.

Disposition of solid waste is as follows: 58% is recycled, 38% is burned for energy recovery at the Maine Energy Recovery Incinerator, and 4% is landfilled at licensed off-site facilities. Bulk aqueous waste is collected and shipped for off-site licensed treatment/disposal. Containerized hazardous waste is collected, consolidated, characterized, and labeled at the shipyard's state-licensed Hazardous Waste Storage Facility prior to manifesting to off-site licensed treatment/disposal/energy recovery facilities. Oily waste is presently contracted for off-site disposal; however, an oily waste treatment system has been installed and should be on line in the near future. The effluent from treatment operations will be discharged to the sewer, and the separated waste oil will be sold through the Defense Logistics Agency.

Solid radioactive waste materials are packaged in strong, tight containers, shielded as necessary, and shipped to burial sites licensed by the U.S. Nuclear Regulatory Commission or a State under agreement with the U.S. Nuclear Regulatory Commission. Shipyards and other shore facilities are not permitted to dispose of radioactive solid wastes by burial on their own sites. During 1992, approximately 74 cubic yards of routine low-level radioactive waste containing 2 curies were shipped from Portsmouth Naval Shipyard for burial.

Waste which is both radioactive and chemically hazardous is regulated under both the Atomic Energy Act and the Resource Conservation and Recovery Act (RCRA) as "mixed waste." Within the Naval Nuclear Propulsion Program, concerted efforts are taken to avoid combining radioactive and chemically hazardous substances so as to minimize the potential for generation of mixed waste. For example, these efforts include avoiding the use of acetone solvents, lead-based paints, lead shielding in disposal containers, and chemical paint removers. Radioactive wastes, including those containing chemically hazardous substances, are handled in accordance with long-standing Program radiological requirements. Such handling includes solidification to immobilize the radioactivity, separation of the radioactive and chemically hazardous substances, removal of liquids from solids, and other simple techniques. A determination is then made as to whether the resulting waste is hazardous. As a result of Program efforts to avoid the use of chemically hazardous substances in radiological work, Program activities typically generate only a few hundred cubic feet of mixed waste each year. This small amount of mixed waste, along with limited amounts of mixed waste from Program work conducted prior to 1987, will be stored pending the licensing of commercial treatment and disposal facilities.

4.1.4 PEARL HARBOR NAVAL SHIPYARD: PEARL HARBOR, HAWAII

4.1.4.1 Overview

The Pearl Harbor Naval Shipyard is located in the Southeast Loch of Pearl Harbor, Oahu, Hawaii (Figures 4.1.4-1 and 4.1.4-2). This shipyard consists of approximately 350 acres. The island of Oahu is the third largest (593 square miles) in the State of Hawaii and is the population center of the Hawaiian Islands. The 1990 Oahu population of approximately 820,000 residents comprised over 75% of the state's total, and the City and County of Honolulu are the fastest growing areas in the state, with the highest population densities. Honolulu is the state capital, largest city, and center of business and government.

Pearl Harbor is a principal harbor for U.S. Navy activities and is the base of Navy operations for the mid-Pacific. Figure 4.1.4-3 provides a Pearl Harbor site map. Its water surface area of about 8 square miles and its docks accommodate all classes of Navy vessels up to the largest aircraft carriers. Ship maintenance and repairs are performed for all types of vessels in Pearl Harbor Naval Shipyard's dry docks and docking areas. All of the docks are located in the Southeast Loch area with the exception of Dry Dock 4 which is adjacent to the Pearl Harbor main channel. (Navy 1991c)

4.1.4.2 Land Use

There are six major land use activities at Pearl Harbor. Commander Naval Base Pearl Harbor (NAVBASE) hosts various operational commands that include the Headquarters for the Pacific Fleet and the Headquarters of the Third Fleet.

Pearl Harbor Naval Shipyard provides the maintenance and repair services noted above. The Naval Supply Center provides fuel, ammunition, other supplies, and storage. The other primary land use activities are for: the Submarine Base; the Public Works Center; and the U.S. Naval Inactive Ship Maintenance Detachment.

Land use is designated as urban by the State of Hawaii, and military by the City and County of Honolulu. As can be seen in Figure 4.1.4-2, the Pearl Harbor Naval Shipyard is surrounded by military land with Hickam Air Force Base in the southern quadrant and naval installations occupying the remaining three quadrants. Other activities commonly occurring in the Pearl Harbor area are commercial fishing, tourism, and recreational facilities, along with a few retail complexes. (Navy 1990b)

Figure 4.1.4-1. Location of Pearl Harbor Naval Shipyard in Hawaii. Figure 4.1.4-2. Pearl Harbor vicinity with average annual rainfall gradient. Figure 4.1.4-3. Pearl Harbor Naval Shipyard site map.

4.1.4.3 Socioeconomics

Oahu has experienced a high rate of economic growth over the past decade due to its location in the Pacific, which benefits both military defense and visitor industries. These two industries have surpassed the two historical bases of the Hawaiian economy, which are pineapple and sugar cultivation and production.

Oahu's visitor industry continues to prosper. Visitor arrivals to the state are projected by the Department of Business and Economic Development to reach 7.8 million visitors by 2000, with Oahu capturing approximately half of the visitors. This would represent a visitor growth rate on Oahu of about 3.4 percent compounded annually.

Defense expenditures cushion Oahu's economy from the seasonal and cyclical fluctuations of tourism. The military is also a primary source of highly skilled employment opportunities for civilians. Pearl Harbor has the largest concentration of Department of Defense employment in the state, with about 7,700 shore-based Navy personnel and 10,900 civilians, for a total of 18,600 at the naval base. In 1993, shipyard employment accounted for about 5,000 of the total. The population distribution within 50 miles of Pearl Harbor Naval Shipyard is shown in Figure 4.1.4-4.

Unemployment figures in the state and for the island of Oahu are among the lowest in the nation. Oahu is at a 2.3 percent unemployment level as of October 1989, reflecting the strong local economy that prevailed in the latter half of the 1980s. With the outlook favorable for continued expansion, job growth is currently expected to equal or better the 2 to 3 percent historical annual increase in Oahu's work force. (Navy 1990b)

Figure 4.1.4-4. Population distribution within 50 miles of Pearl Harbor Naval Shipyard.

The majority of the labor force that would be employed at the shipyard for construction and operation of the naval spent nuclear fuel area would be expected to reside on the island of Oahu. The calculated total population, labor force, and employment within this region for the base year (1995) are presented in Table 4.1.4-1. Projections of employment and population for the years beyond 1995 have not been presented because, as discussed in Section 5, the number of additional jobs that might be created at the shipyard under any alternative could be small.

Table 4.1.4-1. Regional employment factors at Pearl Harbor Naval Shipyard.

Regional Employment	Regional Labor Force	Regional Population
393,260	407,530	812,190

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," requires federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs and activities on minority and low-income populations. An adverse environmental impact is a deleterious environmental impact determined to be unacceptable or above generally accepted norms. A disproportionately high impact refers to an impact (or risk of an impact) in a low-income or minority community that significantly exceeds that on the larger community. Data available from the U. S. Census of 1990 have been used to develop information on the locations of minority and low-income populations within approximately 50 miles of the Pearl Harbor Naval Shipyard, consistent with the population data provided in Figure 4.1.4-4.

Figure 4.1.4-5 shows the locations of populations which have more than 50 percent minority members within the 50-mile radius. Minorities make up approximately 55 percent of the total population in this area. These populations have been identified following an approach developed by the Environmental Protection Agency which, for purposes of environmental justice evaluation, defines minority communities as those which have percentages of minorities greater than the average in the region analyzed (EPA 1994).

Figure 4.1.4-6 shows the locations of populations which have more than 25 percent of their members living in poverty, reflecting a common definition of low-income communities (EPA 1993). The U. S. Census Bureau characterizes persons in poverty as those whose income is less than a "statistical poverty threshold." For the 1990 census, this threshold was based on a 1989 income of $12,500 per household.

Figure 4.1.4-5. Minority population distribution within 50 miles of the Pearl Harbor Naval Shipyard.

Figure 4.1.4-6. Low-income population distribution within 50 miles of the Pearl Harbor Naval Shipyard.

4.1.4.4 Cultural Resources

Pearl Harbor has been the site of several important historical events and changes, and is most noted for its role in the Pacific Theatre Defense during World War II. Physical sites near and in Pearl Harbor have been designated as historically significant, including several battleships sunk during the December 7, 1941 Japanese bombing of Pearl Harbor, as well as sites where planes were downed. Naval Base Pearl Harbor was designated as a National Historic Landmark in 1964, and in 1974, it was listed on the National Register of Historic Places.

The Pearl Harbor area has been heavily modified over the past 70 years. This includes extensive changes that were intended to stabilize the marshy shorelines. Most surface evidence of any pre-military occupation has long since been obliterated. Due to the historic nature of the shipyard, there might be areas of archaeological interest. However, there are no archaeological sites located within the boundary of the shipyard. Many native Hawaiian cultural resources exist on the Hawaiian Islands. There are three Hawaiian fish ponds located outside the boundary, in West Loch and in East Loch, that have been recommended for preservation. (Navy 1990b)

4.1.4.5 Aesthetic and Scenic Resources

The Pearl Harbor viewshed is dominated by the sweeping mountain to sea vistas characteristic of nearshore areas on Oahu. The City and County of Honolulu's Coastal View Study (1987) states that the "flat terrain and the built up military facilities surrounding Pearl Harbor provide very little public viewing opportunities into this bay." (Navy 1990b) The shipyard area, itself, is an industrial setting. The area within the shipyard where naval spent nuclear fuel would be stored has low visual sensitivity since the area is an industrial site.

4.1.4.6 Geology

4.1.4.6.1 General Geology.

Oahu's topography consists of two parallel mountain ranges running in a northwest to southeast direction, separated by a plateau. A large, relatively level coastal plain borders the plateau at the south. The Pearl Harbor Naval Complex, for the most part, lies within this coastal plain.

Land near the waterfront areas is very flat, rising slightly inland from Kamehameha Highway. There are moderate slopes which exist around the rim of the Makalapa Crater.

4.1.4.6.2 Geologic Resources.

There are several different soil associations within the Pearl Harbor basin. The majority of the U.S. Navy lands surrounding Pearl Harbor are comprised of the Lualualei - Fill Land - Ewa Soil Association. This association consists of well-drained, fine textured, and moderate fine textured soils on fans and in drainage ways on the southern and western coastal plains of Oahu. The soils are formed from sediment deposited by streams, and are nearly level to moderately sloping. This soil association makes up about 14 percent of the island of Oahu.

Pearl Harbor estuary occurs on the coastal sedimentary plain of southern Oahu. The harbor consists of three lochs which join to form a single channel entrance. Streams, springs, and ground-water flow into the harbor; the estuary was formed by freshwater flows that have eroded the coastal plain and retarded coral growth. Since their initial formation, the lochs have been altered by sea-level change, erosion, and silt. The west side of the harbor is composed mostly of limestone reef material known as the Ewa Plain. The east side of the harbor consists mainly of compacted volcanic ash. Hard, dense volcanic rock forms the bulk of the rock material to the north. Marine and terrestrial sediments occur around the perimeter of the harbor. (Navy 1990b)

Much of the land area in Pearl Harbor is fill land created by dredge spoils since 1930. A major dredging effort took place between 1940 and 1943, when dredged material was placed in the Waipio Peninsula and adjacent to Kuahua Island (now Kuahua Peninsula). This landfill resulted in the present shoreline configuration. (Navy 1990b) There are no economic geologic resources at the shipyard.

4.1.4.6.3 Seismic and Volcanic Hazards.

Seismic risk related to structural damage may be represented in the United States by a relative scale of 0 through 4, with Zone 0 not expected to encounter damage and Zone 4 expected to encounter the greatest seismic risk. The Pearl Harbor Naval Shipyard is located in Zone 1. (UBC 1991) Except for the island of Hawaii itself, the Hawaiian Islands are not a highly seismic area. Even on Hawaii, most of the earthquakes are of volcanic origin and do little or no damage, although a few have been quite severe. The Uniform Building Code seismic classification provides a means for a comparable assessment of the seismic hazard between the alternate sites. If the Record of Decision identifies this site for the interim storage of naval spent fuel, then a detailed seismic evaluation would be conducted. More detailed information regarding the design basis considerations for storage of naval spent nuclear fuel at the shipyard is provided in Attachment D.

From review of Tsunami Wave Runup Heights in Hawaii by Harold G. Loomis, Hawaii Institute of Geophysics, University of Hawaii, May 1976, past inundation levels from waves produced by seismic events have been about 3 feet above Mean Sea Level (msl). In addition, a memorandum from the U.S. Army Engineering Division, Pacific Ocean, dated 10 January 1986 indicated projected seismically induced wave elevations for the 10-year, 100-year, and 500-year event to be 0.8 feet, 2.0 feet, and 3.8 feet, respectively, for adjacent coastal areas. (Navy 1990b)

Pearl Harbor is fully protected from ocean waves and swells. Waves propagating through the 15,000-foot entrance channel are completely reduced. The normal tides in Hawaii occur twice daily, with pronounced daily inequalities. Maximum high, or spring tides, reach 2.5 feet above msl. Storm water level rise is caused by four components: astronomical tides, rise from atmospheric pressure reduction (pressure setup), wind setup, and wave setup. Based on information obtained from the Naval Western Oceanography Center, maximum hurricane storm water level rise from setup under the worst conditions foreseeable would be approximately 12 feet above the existing tide level. Thus, maximum total storm water level rise would be approximately 14.5 feet above msl. Under the maximum foreseeable conditions, any material stored in the dry dock area of Pearl Harbor Naval Shipyard, which is about 8 feet above msl, could be flooded to a level of about 6.5 feet.

In September 1992, the worst storm in Pacific history, Hurricane Iniki, hit Kauai with sustained 145-mile-per-hour winds and gusts to 175 miles per hour. Oahu, 80 miles to the east, received comparatively minor damage to that experienced on Kauai. The last hurricane to strike the state prior to Iniki was Iwa in 1982 but it did not cause nearly as much damage.

The Hawaiian Islands were formed by volcanic eruptions; however, the only active volcanic area is on the island of Hawaii. There are no volcanic hazards on the island of Oahu. (Doell and Dalrymple 1973).

4.1.4.7 Air Resources

4.1.4.7.1 Climate and Meteorology.

With the exception of minor differences in temperature and rainfall at Red Hill and Camp Stover, all of the activities at Pearl Harbor lie within the same climatic zone and are subject to the same weather conditions.

The predominant winds are the northeast tradewinds, which prevail most of the year, particularly from February to November. Thus, the predominant winds would carry any airborne contaminant from the shipyard to the unpopulated ocean region adjacent to Pearl Harbor on the south. At certain times of the year, south to southwest winds and mild offshore breezes can be expected. Winds with speeds up to 49 miles per hour may occasionally strike from the north or northeast but rarely reach gale velocities. The south winds are usually accompanied by wet tropical air and frequent heavy showers. During the summer months, periods of no wind occur occasionally but do not persist for more than a day or two. During the winter months, winds tend to be less predictable, with longer periods of light and variable winds, and occurrences of strong southerly or "Kona" winds associated with weather fronts and storms.

The rainfall at Pearl Harbor is light and generally inadequate to sustain lawns and other vegetation for at least nine months of the year. Very heavy precipitation may occasionally fall during times of southerly winds, and this may cause local flooding because of the nature of the soils and the relatively low elevation. The mean annual rainfall for the naval base is between 20 and 30 inches, dependent upon the incidence of the occasional heavy southerly rains mentioned previously. The topography and meteorology of Oahu are responsible for the unusual annual rainfall gradient shown in Figure 4.1.4-2.

Temperatures vary by season as well as daily in the Pearl Harbor region. Highs of 87yF to 89yF are not uncommon during mid-afternoon in summer. Night temperatures during the same season fall between 72yF and 76yF. During the winter and early spring, daytime highs will reach between 76yF and 78yF, and nighttime lows may fall to the low 60's or high 50's. The lows are generally caused by a shallow blanket of cold air that pours down from the mountains and spreads out over the lowlands during periods of low-velocity tradewinds. The low temperatures are almost invariably accompanied by a heavy dewfall which is not normal to the region.

4.1.4.7.2 Air Quality.

An area can be designated by the Environmental Protection Agency as having air quality that is better than defined by the National Ambient Air Quality Standards (attainment) or as exceeding one or more of those standards (nonattainment for one or more pollutants). The Code of Federal Regulations, Title 40, Part 81, states that the Air Quality Control Region for the shipyard is better than national standards for total suspended particulate matter and SO_2. The area has no specific classification for ozone, carbon monoxide, and NO_2.

Air quality on Oahu is primarily affected by the prevalence of the northeast tradewinds which prevail approximately 80 percent of the year, particularly from February to November. Air monitoring of the naval base area conducted in 1989 showed that there was no NAAQS violation. Thus, air quality was in attainment with federal standards. The state standards, which are more restrictive in many cases than federal requirements, were exceeded only at intersections having high traffic during peak rush hours. (Navy 1990b) The nearest Class I Area is Haleakala National Park 188 kilometers (117 miles) from the shipyard.

4.1.4.7.3 Existing Radiological Conditions.

Radiological facilities at all naval shipyards are designed to ensure that there are no uncontrolled discharges of radioactivity in airborne exhausts. Radiological controls are exercised to preclude exposure of working personnel to airborne radioactivity exceeding federal limits. Air exhausted from radiological work facilities is passed through high-efficiency particulate air filters and monitored during discharges. The annual airborne radioactivity emissions from the shipyards do not result in any measurable radiation exposure to the general public. Calculations of site radioactive airborne emissions for 1992 have been performed as described in Attachment F. These calculations have shown that emissions of radionuclides from each shipyard result in an effective dose equivalent of less than 0.1 mrem per year to any member of the general public.

4.1.4.8 Water Resources

4.1.4.8.1 Surface Water.

Pearl Harbor receives surface runoff from seven watersheds. The Waikele Watershed (54 square miles) is the largest of the seven, comprising nearly 40 percent of the Pearl Harbor Basin. It is drained primarily by Waikele Stream, which discharges the heaviest sediment load of any of the Pearl Harbor Basin streams.

The Waiawa Watershed (24.6 square miles) consists of forest, agricultural, and urban land. It is drained by Waiawa Stream and its tributaries into Middle Loch. The Waimalu Watershed (17.7 square miles) is drained by the Waimano, Waimalu, and Kalauao Streams, which discharge into the East Loch of Pearl Harbor. The watershed is primarily undeveloped forest land with established urban areas on the coastal plain and lower slopes. The Aiea and Halawa Watersheds are drained by the Aiea and Halawa Streams, respectively, which discharge into East Loch. They are similar in nature to the Waimalu Watershed. Honouliuli Stream drains the Honouliuli Watershed and discharges intermittently into West Loch. The watershed consists primarily of agricultural and forested land. Only 20 percent of the Ewa Beach Watershed drains into Pearl Harbor. Sediment discharges into Pearl Harbor from the flat lowland area adjacent to West Loch are negligible.

Of the eight streams discharging into Pearl Harbor, two are intermittent: Honouliuli Stream and Aiea Stream. The remaining are perennial streams (Waikele, Waiawa, Waimano, Waimalu, Kalauao, and Halawa), which have their headwaters in the high rainfall area of the Koolau Range. All streams drain the forested and agricultural lands and pass through urban areas before entering Pearl Harbor. Some flooding occurs along the major streams throughout much of the basin but is not a major problem on the Naval Complex, affecting only a narrow strip of land along Aiea stream. (Navy 1990b)

An assessment in 1988 by the State of Hawaii, Department of Health indicated that Pearl Harbor's large drainage basin in central Oahu and the abundant rainfall in headwaters of the eight streams that flow into the harbor are major contributors to the harbor's role as a catchment for nonpoint runoff from agricultural, urban, and military sources. Violations of water quality criteria were noted for nitrogen, phosphorus, turbidity, and fecal coliforms in the harbor water. (Navy 1990b)

The Flood Insurance Rate Map (FIRM) COMMUNITY-PANEL No. 150001 0110 C shows that the floodplain is "undetermined" for the Pearl Harbor Naval Shipyard. Based on FIRM maps and topographical maps of areas approximately 3 miles away, the conceptual interim storage location is in the 100-year floodplain. However, based on experience, the location considered for naval spent nuclear fuel is not in a high-hazard area (as defined by Title 10, Part 1022 of The Code of Federal Regulations for floodplains) which is an area where frequent flooding occurs.

4.1.4.8.2 Groundwater.

The major source of potable water on Oahu is dependent on a hydrologic cycle that starts with evaporation of water from the ocean, condensation of that vapor into rain, and the capture of that rain by the Koolau Mountains. A portion of the rainwater percolates down into the porous ground to become groundwater. The groundwater is a limited resource found in three types of groundwater bodies, or aquifers: major basal aquifers, which consist of freshwater floating on heavier seawater sealed from the ocean by layers of dense, hard volcanic rock; perched aquifers in which rainfall is caught behind impermeable dikes at high elevations; and groundwater standing on impermeable beds of volcanic ash, thus creating springs. Naval Base Pearl Harbor receives most of its water from the Koolau Aquifer and a small portion from the Waianae Aquifer, which are basal aquifers located in south central Oahu, partially within the Pearl Harbor Water Management Area (PHWMA). As of 1990, the military had an allocation of 28.125 million gallons per day (mgd) from the PHWMA, of which 22.670 mgd was authorized for the Navy. Over 4 mgd of this allocation was not used in 1988. Approximately 3 mgd of this unused allocation is attributed to the Navy. The quality of groundwater from the above aquifers is good. (Navy 1990b)

4.1.4.8.3 Existing Radiological Conditions.

The normal activities associated with current naval nuclear operations at all naval shipyards do not result in the intentional discharge of any radioactive liquid effluent. However, there were occasions, primarily in the early 1960's, when measurable levels of radioactivity were discharged with liquid effluent. In all cases, effluent releases were less than permitted under the then current limits imposed by state and federal agencies.

The United States Environmental Protection Agency Office of Radiation Programs has performed monitoring of the water, plant life, aquatic life, and sediment in the vicinity of Pearl Harbor Naval Shipyard. The purpose of the survey was to determine if operations related to U.S. Navy nuclear warship activities resulted in releases of radionuclides which could contribute to significant population exposure or contamination of the environment. "Radiological Surveys of the Pearl Harbor Naval Shipyard and Environs" (Callis 1987) is the most recent Environmental Protection Agency report which discusses data taken in 1985. Pertinent conclusions from this report are as follows:

1. "Neither harbor water nor drinking water from surrounding areas contain detectable cobalt-60 or tritium radioactivity.
2. Very small quantities of cobalt-60 were found in sediment and in two aquatic vegetation samples from the harbor. No cobalt-60 was found in any of the aquatic life samples.
3. The levels of cobalt-60 in the harbor sediment have decreased significantly since the surveys of 1966 and 1968 and are consistent with those expected from the radioactive decay of the amounts found in the 1966 and 1968 surveys.
4. The current practice of restricting the release of radioactive material into the harbor to the minimum practical has been effective and should allow the cobalt-60 radioactivity remaining in harbor sediment to continue to decrease.
5. The levels and locations of radioactivity identified and the limited media in which it was found show that operations related to nuclear-powered warship activities resulted in no release of radionuclides having adverse effects on public health or the environment."

Environmental monitoring is conducted by the shipyard. The results of this monitoring program corroborate the Environmental Protection Agency's conclusion.

4.1.4.9 Ecological Resources

4.1.4.9.1 Terrestrial Ecology.

Because the Pearl Harbor area has been disturbed extensively and for such a long period of time, the vegetation is dominated by introduced or alien species. Vegetation consists of maintained landscaped specimens or, on unmaintained areas, mangrove thickets and weedy scrub. The few native taxa which occur on these unmaintained areas such as 'uhaloa (Waltheria indica) and 'ilima (Sida fallax) occur throughout the Hawaiian Islands and the Pacific in similar environmental habitats. No plants considered threatened or endangered occur on this location.

Fauna in the Pearl Harbor area is also typically urban. In general, various feral and domestic cats and dogs, rodents, and exotic bird species are found in the area. No endemic land birds were recorded during the course of the field surveys completed in 1989. (Navy 1990b)

4.1.4.9.2 Wetlands.

There are several wetland areas at Pearl Harbor identified in the East Loch, Middle Loch, and West Loch, as well as an area on the Waipio Peninsula. There is also a Pearl Harbor National Wildlife Refuge. These are habitats for endangered species of birds, principally the Hawaiian Coot and Hawaiian Stilt. A cooperative agreement established between the U.S. Navy, and the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, and the State of Hawaii, Department of Land and Natural Resources, protects these wetlands. (Navy 1990b)

4.1.4.9.3 Aquatic Ecology.

Most of the Pearl Harbor marine community structure is characterized by four zones: sand-rubble zone, algal-mud zone, channel wall zone, and channel floor mud-silt zone. Sedimentation is the major factor determining the constituents of the Pearl Harbor marine community. Hence, stony corals, which are especially sensitive to high sediment loads, have not been observed. Predominant biota include the sea cucumber (Ophiodesoma spectabilis), a species commonly found in areas of high organic particulate input; benthic (bottom dwelling) algae; sponges; Sabellid (feather duster) worms; Serpulid worm tubes; and various benthic shrimps and crabs. (Navy 1990b)

4.1.4.9.4 Endangered and Threatened Species.

Most of the land at Pearl Harbor Naval Shipyard has been urbanized, and the present vegetation consists almost exclusively of introduced plant species. Consequently, no federally or state listed threatened or endangered species or critical habitats are known to exist within the confines of Pearl Harbor Naval Shipyard. Because the area has been greatly disturbed and the native vegetation completely eliminated, there is little remaining terrestrial habitat of any consequence. Small tracts of weedy fields and isolated pockets of disturbed secondary vegetation within the station's boundaries provide limited habitat for introduced species of birds and rodents. Some migratory birds as well as endemic and indigenous waterfowl species may occasionally frequent the shoreline areas of Pearl Harbor Naval Shipyard, but none are considered residents of the activity. The mangrove stands and associated shoreline habitats act as nurseries to a variety of fish and wildlife and aid in shoreline stabilization and erosion control. (Navy 1989)

Marine mammals are afforded full Federal protection under the Marine Mammal Protection Act of 1972. As noted above, there are wetland areas in the Pearl Harbor Complex that include a National Wildlife Refuge and provide habitats for endangered species of birds, principally the Hawaiian Coot (Fulica americana alai) and Hawaiian Stilt [Himantopus mexicanus (=himantopus) knudseni].

4.1.4.10 Noise

Noise sensitive locations in the Pearl Harbor area have been identified as the U.S.S. Arizona Memorial, U.S.S. Arizona Memorial Visitor Center, U.S.S. Bowfin Park, Marina Restaurant, Richardson Recreation Center, and existing or planned residential areas of Ford Island. Field noise measurements were taken at these locations on December 5, 1989; previous measurements also were taken at some of these locations. All appear to meet state and federal noise standards at present.

Pearl Harbor Naval Shipyard is an existing industrial environment characterized by noise from truck and auto traffic, ship loading cranes and related diesel-powered equipment, and continuously operating transmission lines for steam, fuel, water, and related compressors for these and other liquids. In addition, new construction of buildings, reconstruction and rehabilitation activities for streets, buildings, parking lots, and ships all contribute to the noise associated with an industrial environment. (Navy 1990b)

4.1.4.11 Traffic and Transportation

The main portion of traffic into and out of the base is an aggregate of commuting traffic to work, residential related traffic, and service traffic related to the business of the base. Kamehameha Highway is the primary access route to the base from the Ewa/Pearl City/central Oahu direction. Both Kamehameha Highway and Interstate Highway H-1 provide access to the Naval Base from the Honolulu direction. (Navy 1990b)

The Honolulu International Airport provides scheduled passenger and cargo air service to major connecting hubs. In addition, Hickam Air Force Base services the military.

Naval spent nuclear fuel has been removed from Navy nuclear-powered ships and transported to the Idaho National Engineering Laboratory Expended Core Facility (ECF) for examination and evaluation as a routine part of their operating cycle. Naval spent nuclear fuel shipments from Pearl Harbor Naval Shipyard to ECF were initiated in 1962. Since that time, 20 shipments of naval spent nuclear fuel originating at Pearl Harbor Naval Shipyard have been made to ECF. The naval spent nuclear fuel containers were transported by ship to the Puget Sound Naval Shipyard where the containers were then transported to ECF by rail. Attachment A provides a list of these shipments made to date by year. Attachment A also contains detailed descriptions of the shipping containers used for naval spent nuclear fuel shipments from shipyards.

Traffic circulation related to Naval Base Pearl Harbor is determined by the working and residential populations of the base, by the geometry of the existing roadways and intersections, and by the access gates into the base.

4.1.4.12 Occupational and Public Health and Safety

4.1.4.12.1 Occupational Radiological Health and Safety. The Navy has well established and

effective Occupational Safety, Health, and Occupational Medicine programs at all of its shipyards. In regard to radiological aspects of these programs, the Naval Nuclear Propulsion Program policy is to reduce to as low as reasonably achievable the external exposure to personnel from ionizing radiation associated with naval nuclear propulsion plants. These stringent controls on minimizing occupational radiation exposure have been successful. No civilian or military personnel at Navy sites have ever exceeded the federal accumulated radiation exposure limit which allows 5 rem exposure for each year of age beyond age 18. Since 1967, no person has exceeded the federal limit which allows up to 3 rem per quarter year and since 1980, no one has received more than 2 rem per year from radiation associated with naval nuclear propulsion plants. The average occupational exposure of each person monitored at all shipyards is 0.26 rem per year. The average lifetime accumulated radiation exposure from radiation associated with naval nuclear propulsion plants for all shipyard personnel who were monitored is 1.2 rem. (NNPP 1994a) This corresponds to the likelihood of a cancer fatality of 1 in 2083.

The Navy's policy on occupational exposure from internal radioactivity is to prevent radiation exposure to personnel from internal radioactivity. The limits invoked to achieve this objective are one-tenth of the levels allowed by federal regulations for radiation workers. As a result of this policy, no civilian or military personnel at shipyards have ever received more than one-tenth the federal annual occupational exposure limit from internal radiation exposure caused by radioactivity associated with naval nuclear propulsion plants.

For work operations involving the potential for spreading radioactive contamination, containments are used to prevent personnel contamination or generation of airborne radioactivity. The controls for contamination are so strict that precautions sometimes have had to be taken to prevent tracking contamination from fallout and natural sources into radiological areas because the contamination control limits used in these areas were well below the levels of fallout and natural contamination occurring outside in the general public areas. A basic requirement of contamination control is monitoring all personnel leaving any area where radioactive contamination could possibly occur. Workers are trained to survey themselves (i.e., frisk), and their performance is checked by radiological control personnel. Frisking of the entire body is required, normally using sensitive hand-held survey instruments. Major work facilities are equipped with portable monitors, which are used in lieu of hand-held friskers. These stringent controls to protect the workers and the public from contamination have proven effective in the past.

In 1991, researchers from Johns Hopkins University, Baltimore, Maryland, completed a very comprehensive epidemiological study of the health of workers at the six naval shipyards and two private shipyards that service the Navy's nuclear-powered ships (Matanoski 1991). This independent study evaluated a population of 70,730 civilian workers over a period from 1957, beginning with the first overhaul of the first nuclear-powered submarine, USS NAUTILUS, through 1981, to determine whether there was an excess risk of leukemia or other cancers associated with exposure to low levels of gamma radiation.

The Johns Hopkins study found no evidence to conclude that the health of people involved in work on U.S. naval nuclear-powered ships has been adversely affected by exposure to low levels of radiation incidental to this work. Additional studies are planned to investigate the observations and update the shipyard study with data beyond 1981.

The radiation exposure during normal operations at each shipyard for workers who have their radiation levels monitored is determined based on the annual radiation exposure of 0.26 mrem per worker for all shipyards based on Naval Nuclear Propulsion Program Report NT-94-2 (NNPP 1994a). The total number of shipyard personnel monitored for radiation exposure associated with the Naval Nuclear Propulsion Program has been about 164,000.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. The radiation exposure to transportation workers for all historical shipments is 16.6 person-rem, which statistically corresponds to 0.0066 cancer fatalities. The maximum exposed individual (MEI) is a transportation worker, since the workers are closer to the shipment for a longer time than any member of the general population.
Under the limiting assumption that the same worker is associated with every shipment for the entire historical period, this person would receive a total exposure of 7.5 rem over the approximately 40-year period, or about 0.19 rem per year, which is within DOE standards for occupationally exposed individuals. The radiation exposures to workers correspond to much less than one incident cancer, which means that it is unlikely that there have been any past health impacts due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.4.12.2 Occupational Non-radiological Health and Safety.

In the non-radiological Occupational Safety, Health, and Occupational Medicine area, the Navy complies with the Occupational Safety and Health Administration Regulations. The Navy's policy is to maintain a safe and healthful work environment at all naval facilities. Due to the varied nature of work at these facilities, there is a potential for certain employees to be exposed to physical and chemical hazards. These employees are routinely monitored during work and receive medical surveillance for physical hazards such as exposure to high noise levels or heat stress. In addition, employees are monitored for their exposure to chemical hazards such as organic solvents, lead, asbestos, etc., and where appropriate are placed into medical surveillance programs for these chemical hazards.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. Approximately 0.028 fatalities are estimated as a result of non-radiological sources (vehicle emissions) associated with all historical shipments of spent nuclear fuel. This number includes both the workers and the general public. Since this number is much less than one, it is unlikely that there has been any non-radiological health impact due to the historical shipment of naval spent nuclear fuel over the entire history of such shipments.

4.1.4.12.3 Public Radiological Health and Safety.

In order to quantify the exposures resulting from normal shipyard radiological releases to the general public, detailed analyses were performed based on very conservative estimates of radioisotopic releases from 1961 through 1992. Attachment F provides detailed annual release values used in the analyses.

The GENII computer code (Napier et al. 1988) was used to calculate exposures to human beings due to the estimated radionuclide releases from normal operations at the shipyards.

A person on the shipyard boundary at the location where the largest exposures would be received was used as the hypothetical maximally exposed off-site individual (MOI) for postulated releases of radioactive material from stored fuel. The population data used to calculate population exposures were taken from 1990 census data provided by the U.S. Census Bureau. Meteorology data were obtained as described in Attachment F.

The hypothetical exposures calculated in Attachment F for the period 1995 through 2035 were adjusted from an annual basis (1995) to the historical basis by multiplying by 38 years and by a factor of 1.7 to take into consideration variations in the number of ships and operations.

The calculated accumulated exposures through 1995 to the general population within 50 miles of the site (about 0.8 million people) are 1.9 person-rem. To provide perspective, the exposures received due to natural radiation sources through 1995 are approximately 9.3 million person-rem, based on 0.3 rem per person per year.

The results of environmental monitoring as described in Naval Nuclear Propulsion Program Report NT-94-1 show that Naval Nuclear Propulsion Program activities had no distinguishable effect on normal background radiation levels at site perimeters (NNPP 1994b).

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. The radiation exposure to the general population for all historical shipments is 1.95 person-rem, which statistically corresponds to 0.00098 cancer fatalities.

All of the radiation exposures to the general population correspond to much less than one incident cancer, which means that it is unlikely that there has been any past health impact to the public due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.4.12.4 Public Non-radiological Health and Safety.

The military is responsible for providing health care services for its personnel and dependents. Navy families receive both in-patient and out-patient care at Tripler Army Medical Center. Services are also provided at on-base clinics and dispensaries. Active-duty personnel are required to use military health care facilities. In addition, military dependents have the option of going to private providers and being partially reimbursed for the cost.

The Oahu Civil Defense Agency is responsible for developing, preparing, and assisting in the implementation of civil defense plans and programs to protect the safety, health, and welfare of island residents during disasters and emergency situations. However, responsibility for military personnel and dependents on the base rests with the Navy.

Fire protection within Naval Base Pearl Harbor is provided by the Federal Fire Department. A Mutual Aid Pact between the federal (military) fire departments and the Honolulu Fire Department affords dual coverage in times of emergencies.

Naval Base Pearl Harbor is under federal jurisdiction; therefore, federal authorities are normally responsible for providing all needed police service. The City and County of Honolulu Police Department, however, is responsible for traffic control in areas around the base. The closest police station is located in Pearl City. (Navy 1990b)

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. Approximately 0.028 fatalities are estimated as a result of non-radiological sources (vehicle emissions) associated with all historical shipments of spent nuclear fuel. This number includes both the workers and the general public. Since this number is much less than one, it is unlikely that there has been any non-radiological health impact to the public due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.4.13 Utilities and Energy

4.1.4.13.1 Water Consumption. Naval Base Pearl Harbor receives most of its water from the

Koolau Aquifer and a small portion from the Waianae Aquifer, which are basal aquifers located in south central Oahu, partially within the Pearl Harbor Water Management Area (PHWMA). In early 1989, a Water Management Plan for the PHWMA was proposed by the Commission on Water and Resource Management (CWRM) to preserve and manage the Koolau and Waianae basal aquifers and the Schofield high-level aquifer. One important portion of the Water Management Plan recommended that the sustainable yield for the PHWMA be revised downward from the then current 225 million gallons of water per day (mgd) to 195 mgd. The purpose of the revision was to eliminate possible shrinkage of the aquifer in the PHWMA from over-withdrawal. Actual use in 1989 totaled 198.298 mgd, of which the military portion was about 13 percent. The major water users in the PHWMA are the Board of Water Supply (87.5 mgd) and the Oahu Sugar Company (78.6 mgd). In the revised plan, water allocation to the military is not decreased. The stated management policy of the CWRM is that "total allocation of authorized use will not at any time exceed sustainable yield." As of 1990, the military had an allocation of 28.125 mgd from the PHWMA, of which 22.670 mgd was authorized for the Navy. Of the total allocation to the U.S. Navy, Koolau Aquifer provides 20.333 mgd, and Waianae Basal Aquifer provides 2.337 mgd. (Navy 1990b)

4.1.4.13.2 Electricity Consumption.

The electrical power service for the Pearl Harbor Naval Complex is provided by the Hawaiian Electric Company. The Hawaiian Electric Company power grid on the island of Oahu consists of three power plants with a total capacity of 1,271 MW, plus two plants in planning or under construction totaling 390 MW. The peak island demand in 1989 was approximately 1,090 MW.

The power plants are located at Kahe, Waiau, and downtown Honolulu and are inter-connected via 138-kV transmission and 46-kV sub-transmission circuits. The Pearl Harbor Naval Complex is served via three 46-kV feeders, each from a separate 80-MVA transformer at the Makalapa substation, which is part of the island's 138-kV grid. The feeders serve two Hawaiian Electric Company substations located on the base (Puuloa and Kuahua), which step the voltage down to 11.5 kV, and serve two normally separated 11.5-kV networks.

One of the 46-kV feeders serves only the Puuloa substation. The second serves only the Kuahua substation. The third serves both substations. Any one feeder has the capacity to carry the entire Pearl Harbor load or approximately 57 MVA. In addition to the three feeders from the Makalapa substation, there are two alternate 46-kV circuits, one a dedicated spare, from the Waiau power plant.

The Puuloa substation consists of two 20/33-MVA transformers located in the Pearl Harbor Naval Shipyard area and serves the Pearl Harbor Naval Shipyard, Naval Station Pearl Harbor, and Ford Island. The Kuahua substation consists of two 15/20-MVA transformers located in the Submarine Base Pearl Harbor area and serves the Submarine Base Pearl Harbor and Naval Supply Center Pearl Harbor areas.

4.1.4.13.3 Fuel Consumption.

One major type of energy use is vehicular fuel consumption. No estimates are available to differentiate vehicle fuel use at Pearl Harbor from other areas. The ferry system consumed 152,088 gallons of diesel fuel in 1988. An occupancy rate of 1.5 persons per vehicle was used, so the ratio of fuel consumed per person per trip was 0.144 gallon of diesel fuel per person crossing. The second major source of energy consumption originates in buildings. The analysis of building energy use is based on standards for energy consumption per unit of designated building floor area by type of building and the geographical location.

4.1.4.13.4 Wastewater Systems and Discharges.

Sewage at the Pearl Harbor Naval Complex is collected and treated in several separate systems. Most of the sewage generated by U.S. Navy shore activities and family housing areas receives secondary treatment at Navy-operated sewage treatment plants. The largest volume is treated at the Fort Kamehameha Sewage Treatment Plant which serves the Naval Station Pearl Harbor, Pearl Harbor Naval Shipyard, Naval Supply Center Pearl Harbor Complexes, Camp Smith, Navy and Air Force housing areas, Hickam Air Force Base, and other adjacent military areas.

4.1.4.13.5 Energy Conservation.

To minimize the use of fossils fuels and conserve energy, the military has adopted conservation criteria for new construction and major renovation projects. The policies used under the conservation criteria focus on meeting design energy targets, based on Btu/per square foot/per year (Btu/sf/yr). Guidelines are provided for ventilation, insulation, and energy life cycle cost of structures. (Navy 1990b)

4.1.4.14 Materials and Waste Management

The City and County of Honolulu's HPOWER (Honolulu Program of Waste Energy Recovery) "garbage-to-energy" facility at Campbell Industrial Park is currently in full operation and burning roughly 1,500 to 1,800 tons per day, which is most of the combustible rubbish generated on the island of Oahu. Approximately 20 percent (by weight) of the refuse handled by the HPOWER facility is reduced to ash and other residue which requires landfill disposal.

There are two city and county landfills: the Kapaa Landfill in Kailua (Windward Oahu) and the Waimanalo Gulch Landfill in Nanakuli (Leeward Oahu). The Kapaa Landfill has reached full capacity, and plans are underway to locate a new site in Windward Oahu. The Nanakuli facility, which opened in September 1989, is programmed for 1,000 tons per day for seven to eight years. According to the city, the facility should be able to accommodate projected needs for at least 15 years and maybe longer. (Navy 1990b)

Solid radioactive waste materials are packaged in strong, tight containers, shielded as necessary, and shipped to burial sites licensed by the U.S. Nuclear Regulatory Commission or a State under agreement with the U.S. Nuclear Regulatory Commission. Shipyards and other shore facilities are not permitted to dispose of radioactive solid wastes by burial on their own sites. During 1992, approximately 110 cubic yards of routine low-level radioactive waste containing a total of 1 curie were shipped from the shipyard for burial.

Waste which is both radioactive and chemically hazardous is regulated under both the Atomic

Energy Act and the Resource Conservation and Recovery Act as "mixed waste." Within the Naval Nuclear Propulsion Program, concerted efforts are taken to avoid commingling radioactive and chemically hazardous substances so as to minimize the potential for generation of mixed waste. For example, these efforts include avoiding the use of acetone solvents, lead-based paints, lead shielding in disposal containers, and chemical paint removers. Radioactive wastes, including those containing chemically hazardous substances, are handled in accordance with long-standing Program radiological requirements. Such handling includes solidification to immobilize the radioactivity, separation of the radioactive and chemically hazardous substances, removal of liquids from solids, and other simple techniques. A determination is then made as to whether the resulting waste is hazardous. As a result of Program efforts to avoid the use of chemically hazardous substances in radiological work, Program activities typically generate only a few hundred cubic feet of mixed waste each year. This small amount of mixed waste, along with limited amounts of mixed waste from Program work conducted prior to 1987, will be stored pending the licensing of commercial treatment and disposal facilities.

4.1.5 KENNETH A. KESSELRING SITE: WEST MILTON, NEW YORK

4.1.5.1 Overview

The Kenneth A. Kesselring Site of the Knolls Atomic Power Laboratory (KAPL) is located in the mid-eastern sector of New York State as shown on Figure 4.1.5-1. The Site is located near West Milton in Saratoga County, New York at 43y2'28" north latitude and 73y57'13" west longitude. This United States Government owned reservation consists of over 3900 acres centered about 15 miles north of the city of Schenectady and about 8 miles west of Saratoga Springs. The Site includes three operating naval nuclear propulsion prototype plants and support facilities. The Site also includes one prototype plant that is in the process of being permanently shut down; one of the three operating plants is currently scheduled to be shut down in 1996. All the operating facilities are located in a secure area near the center of the reservation (see Figure 4.1.5-2). A more detailed illustration of the site is provided in Figure 4.1.5-3.

4.1.5.2 Land Use

All the land within the Site perimeter is owned by the Department of Energy (DOE). There are no permanent residents within this area. The surrounding region, within 50 miles of the Site, contains a population of about 1,150,000 as obtained from the 1990 census.

Most of the land surrounding the Site is either wooded or is used for farming, with some residential areas. Both dairy farms and agricultural farms are located in the immediate vicinity of the reservation.

The West Milton area is located within the undulating transition zone between the Adirondack Highlands and the Hudson-Mohawk Lowlands physiographic provinces. The area is characterized by a series of irregular northwest-southwest trending topographic steps that descend from the highlands southeasterly towards the lowlands.

Figure 4.1.5-1. Kesselring Site vicinity map. Figure 4.1.5-2. Kesselring Site location map. Figure 4.1.5-3. Kesselring Site map.

Ground elevations in the vicinity of the reservation range from 400 to 900 feet above mean sea level. The Glowegee Creek, its various tributaries, and the Crook Brook drain the reservation. The developed portion of the reservation, which contains the prototype plants, consists of approximately 50 acres (see Figure 4.1.5-2). The terrain surrounding the Site forms a partial bowl having a bottom diameter of about 2000 feet and a maximum height of 150 feet. The Site is essentially flat-lying with ground elevations ranging from 480 to 490 feet. The western half of the Site is surrounded by elliptical hills approximately 600 feet in elevation. Drainage from the Site is eastward, to the Glowegee Creek.

4.1.5.3 Socioeconomics

As of 1993, the Kesselring Site employed about 1,450 civilian workers, and about 1,250 naval personnel worked at the Site.

The only industry within 4 miles of the Site is the Cottrell Paper Company, located in Rock City Falls, about 3 miles from the Site.

The region surrounding the Site, within 50 miles, contains a population of about 1,150,000 as obtained from the 1990 census. Figure 4.1.5-4 provides a population distribution rose centered on the Site and lists the total population within concentric rings covering a 50-mile radius from the Site.

The majority of the labor force that would be employed at the Site for construction and operation of the naval spent nuclear fuel area would be expected to reside within about 20 miles from the Site. The calculated total population, labor force, and employment within this region for the base year (1995) are presented in Table 4.1.5-1. Projections of employment and population for the years beyond 1995 have not been presented because, as discussed in Section 5, the number of additional jobs that might be created at the Site under any alternative could be small.

Table 4.1.5-1. Regional employment factors at the Kesselring Site.

Regional Employment	Regional Labor Force	Regional Population
165,830	176,600	373,970

Figure 4.1.5-4. 50-mile population distribution around the Kesselring Site.

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," requires federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs and activities on minority and low-income populations. An adverse environmental impact is a deleterious environmental impact determined to be unacceptable or above generally accepted norms. A disproportionately high impact refers to an impact (or risk of an impact) in a low-income or minority community that significantly exceeds that on the larger community. Data available from the U. S. Census of 1990 have been used to develop information on the locations of minority and low-income populations within approximately 50 miles of the Kesselring Site, consistent with the population data provided in Figure 4.1.5-4.

Figure 4.1.5-5 shows the locations of populations in which minority membership exceeds the average within the 50-mile radius by more than 20 percentage points and populations which have more than 50 percent minority members. These populations have been identified following an approach developed by the Environmental Protection Agency which, for purposes of environmental justice evaluation, defines minority communities as those which have percentages of minorities greater than the average in the region analyzed (EPA 1994).

Figure 4.1.5-6 shows the locations of populations which have more than 25 percent of their members living in poverty, reflecting a common definition of low-income communities (EPA 1993). The U. S. Census Bureau characterizes persons in poverty as those whose income is less than a "statistical poverty threshold." For the 1990 census, this threshold was based on a 1989 income of $12,500 per household.

4.1.5.4 Cultural Resources

Historically, the Kesselring Site reservation was used for agricultural purposes. Although old farmhouse foundations, grove sites, stone walls, and land fences exist on the Kesselring Reservation, there are no known archaeological, cultural, or Native American sites in the secure area of the Kesselring Site (USAEC 1972). There are no historic structures on the Site that are potentially eligible for or are listed on the National Register of Historic Places (NPS 1991).

Figure 4.1.5-5. Minority population distribution within 50 miles of the Kesselring Site.

Figure 4.1.5-6. Low-income population distribution within 50 miles of the Kesselring Site.

4.1.5.5 Aesthetic and Scenic Resources

The Kesselring Site is located in an area of moderately undulating topography at the northern edge of the Hudson-Mohawk Lowlands. Most of the Site facilities including the prototype reactor plants are located within a fenced security area. This security area and adjacent parking lots are located near the center of the Government reservation. (UE&C 1973) Since the balance of the reservation consists of wooded lands, there is very little public viewing opportunity of the Site facilities from the boundaries of the Government reservation. The area within the Site fenced security region where naval spent nuclear fuel would be stored has low visual sensitivity since the area is an industrial site.

4.1.5.6 Geology

4.1.5.6.1 General Geology.

In 1973, a Site evaluation and foundation engineering investigation were conducted for the Kesselring Site (UE&C 1973) to establish suitable parameters for the analysis and design of the S8G prototype structures. A prior evaluation of the Site was conducted for the Modifications and Addition to Reactor Facilities. In both investigations, the local and regional geology and seismicity of the West Milton area were examined through a literature search, a detailed subsurface investigation, and a geophysical survey involving refraction and cross-hole velocity measurements. Major soil boring, sampling, and laboratory testing for the S8G Site evaluation were reported in various documents (UE&C 1973; EDCE 1974a; EDCE 1974b). Additional boring information and a geophysical field investigation performed for the Modifications and Addition to Reactor Facilities project were also utilized in the S8G Site evaluation. A 1974 Site geology evaluation was also conducted and a report issued (DGC 1974).

4.1.5.6.2 Geologic Resources.

At Kesselring, unconsolidated materials, primarily of glacial origin, overlie bedrock. The thickness of these materials or overburden sequence is variable, ranging from 0 to several hundred feet. The overburden sequence, in ascending order, consists of three basic kinds of depositional units: glacier debris, lake, and ice-contact/outwash deposits. Deposits from glaciers overlie much of the bedrock and form the elliptical hills (drumlins) throughout most of the reservation. The glacier deposits are a dense and poorly sorted mixture of clay, silt, sand, gravel, and boulders. Thinly stratified lake clay and silt deposits are mapped over the reservation's southeastern quadrant. The ice-contact/outwash deposits mostly consist of stratified sands and gravels. The ice contact/outwash deposits, characterized by low clay and silt content, have better aquifer potential than the silt-and-clay-rich glacier and lake deposits.

Bedrock geology is also variable at the reservation and consists of crystalline rocks, Potsdam Sandstone, Galway Formation (dolomites and sandstones), Gailor Dolomite, Trenton/Amsterdam/ Lowville Limestones, and Canajoharie Shale. The Canajoharie Shale underlies the majority of the reservation. This black shale generally is considered a poor aquifer and its productivity is dependent on the presence or absence of fractures. Also, its water may contain naturally occurring hydrogen sulfide.

At the Site, approximately 20 to 30 feet of overburden deposits overlie the Canajoharie Shale. These deposits consist of layers of deposits from glaciers and lakes. Locally, these deposits have been altered as the result of facility construction. Generally, groundwater exists from 5 to 10 feet below the ground surface. Groundwater flows easterly, toward the nearby Glowegee Creek.

There are no economic geologic resources at the Site.

4.1.5.6.3 Seismic and Volcanic Hazards.

In 1973, a seismicity evaluation of the Kesselring Site was conducted (UE&C 1973). An additional investigation was conducted in 1981 (EDCE 1981). The following is a summary of their findings.

Three branch faults exist in the vicinity of the Site: The West Galway, the East Galway, and the Rock City Falls faults. These branch faults are the lines of demarcation between the various bedrock formations in the immediate area. The East Galway branch lies approximately 3500 feet northwest of the Site and is believed to be the predominant influence on the earthquake loading for Site facilities. The two Galway faults are end branches of the Hoffman's Ferry fault.

Seismic risk related to structural damage may be represented in the United States by a relative scale of 0 through 4, with Zone 0 not expected to encounter damage and Zone 4 expected to encounter the greatest seismic risk. The Site is located in Zone 2A according to the "Uniform Building Code" (UBC 1991). The Uniform Building Code seismic classification provides a means for a comparable assessment of the seismic hazard between the alternate sites. If the Record of Decision identifies this site for the interim storage of naval spent fuel, then a detailed seismic evaluation would be conducted. More detailed information regarding the design basis considerations for storage of naval spent nuclear fuel at the Site is provided in Attachment D.

Data accumulated indicate that the maximum intensity earthquake for the region within a 100-mile radius of the Site had a value of VII. The most recent earthquake of that intensity occurred at Lake George, New York, on April 30, 1931. It is postulated that this event had an epicenter at the point where the Rock City Falls fault meets the Hoffman's Ferry fault. Since the West Galway and East Galway branch faults are extensions of the Hoffman's Ferry fault, an earthquake of similar intensity might occur anywhere along the East Galway fault within the lifetime of the Site structures.

Several earthquakes having an intensity VIII or greater have occurred at distances greater than 100 miles from the Site. However, due to attenuation effects, the ground motion at the Site associated with these earthquakes has not been greater than that equivalent to an intensity VI. The most recent event occurred in 1983 at Newcomb, New York (about 75 miles northwest of the Site) and was of intensity VI.

Details regarding the seismic characteristics of the area and the design bases seismic evaluations performed for the Kesselring Site are provided in the "Site Geology Evaluation Report - S8G for Kesselring Site" (UE&C 1973) and in "Geotechnical Site Investigation, Kesselring Site, West Milton, New York" (EDCE 1981).

There are no volcanic hazards in the vicinity of the Site.

4.1.5.7 Air Resources

4.1.5.7.1 Climate and Meteorology.

The east-central part of New York State, in which the West Milton area is located, is situated at the northern end of the Hudson River Valley and is approximately 150 miles inland from the Atlantic coastline and about 200 miles south of the Canadian border. The climate of the region is primarily continental in character, but is subjected to some modification by the Atlantic Ocean. The moderating effect on temperatures is more pronounced during the warmer months than in winter when outbursts of cold air sweep down from Canada. In the warmer seasons, temperatures rise rapidly in the daytime, but also fall rapidly after sunset so that the nights are relatively cool. Occasionally, there are extended periods of oppressive heat up to a week or more in duration.

During the winter months, winds are generally from the west or northwest. During the warmer months, the winds are from the south. Wind velocities are moderate, and generally average less than 10 mph. Destructive winds (i.e., winds in excess of 80 mph) occur infrequently and tornadoes are rare. Tornadoes are rare in the region served by the Albany, New York weather station.

The mean monthly temperature of the region is about 50yF. Daily extremes can range from -30yF in the winter months to 100yF in the summer. On an annual basis, the mean daytime relative humidity values range from 50 to 80 percent. During the summer months, relative humidity values frequently approach 100 percent during the night.

Total yearly precipitation averages about 36 inches. The average yearly snowfall is about 58 inches and the maximum snowfall in 24 hours is about 22 inches. On the average, a frost depth of about 3 feet can be expected.

For weather reporting purposes, the West Milton area of northeastern New York is included in the National Weather Service Zone Forecast for Saratoga County. The principal weather recording location is at the Albany, New York airport. Its elevation is 275 feet above mean sea level. Because of the proximity of West Milton to Albany, temperature data for the Site should differ little from the Albany data. The two locations are generally within one or two degrees of each other, with West Milton tending to have lower temperatures.

4.1.5.7.2 Air Quality.

The principal sources of industrial gaseous effluents from the Kesselring Site are two 21-million, one 30-million, and one 110-million Btu/hr steam generating boilers. The number 2 fuel oil that is used to fire all of the boilers contains less than 0.5 weight percent sulfur. Combustion gases from the boilers are released through three elevated exhaust stacks. Operations such as ozalid reproduction, carpenter shops, welding hoods, paint shop, and industrial cleaning processes constitute other permitted point sources of airborne effluents. All point source emissions conform to the applicable state and federal clean air standards. Sulfur emitted from all boiler units is monitored via analysis of fuel sulfur content and reported to the Environmental Protection Agency (EPA) on a quarterly basis in compliance with the EPA's New Source Performance Standards in The Code of Federal Regulations, Title 40, Part 60. Sulfur emissions from the boilers are well within the EPA's New Source Performance Standards emission standard for stationary combustion installations. All other industrial emission sources at the Kesselring Site do not require monitoring under terms of the current New York State permits due to the very low levels of the emissions.

An area can be designated by the Environmental Protection Agency as having air quality that is better than defined by the National Ambient Air Quality Standards (attainment) or as exceeding one or more of those standards (nonattainment for one or more pollutants). The Code of Federal Regulations, Title 40, Part 81, states that the Air Quality Control Region for this site is in marginal nonattainment for ozone and is better than national standards for total suspended particulate matter and SO_2. The area has no specific classification for carbon monoxide and NO_2.

The nearest Class I area is at Lye Brook Wilderness, Suarderland, Vermont, which is 46 miles from the Site.

4.1.5.7.3 Existing Radiological Conditions.

Radiological facilities at the Kesselring Site are designed to ensure that there are no discharges of radioactivity in airborne exhausts in excess of prescribed operational limits. Radiological controls are exercised to preclude exposure of working personnel to airborne radioactivity exceeding federal limits. Air exhausted from radiological work facilities is passed through high-efficiency particulate air filters and monitored during discharges. The annual airborne radioactive emissions from Kesselring Site do not result in any measurable radiation exposure to the general public. As described in the "Knolls Atomic Power Laboratory Environmental Monitoring Report for Calendar Year 1992" (KAPL 1992), the estimated 1992 radiation exposure to off-site individuals attributed to radioactive air emissions from Kesselring Site operations was less than 1 percent of the Environmental Protection Agency standards given in Subpart H of 40CFR61 (CFR 1989). In order to quantify the risk of normal (non-accident) Kesselring Site radiological airborne releases to the general public, detailed analyses were performed based on conservative estimates of radioisotopic releases in the exhaust air. In 1992, the airborne radioactivity emissions from the Kesselring Site totaled about 2 curies (KAPL 1992).

4.1.5.7.4 Existing Non-radiological Conditions.

New York State emission standards for all permitted emission sources at the Kesselring Site, with the exception of the site boilers, are stipulated in the individual permits for these sources. State regulations provide specific guidance on what types of emissions require a permit. Compliance with the operating permit is the responsibility of the permit holder under the condition that all planned changes in operating permit conditions require prior review and approval by the New York State Department of Environmental Conservation (NYSDEC). In addition, all operating permits are reviewed and renewed at least every 5 years.

Stationary combustion sources such as the Site's boilers are not specifically regulated by NYSDEC, but fall under the federal New Source Performance Standards in The Code of Federal Regulations, Title 40, Part 60. Compliance with these standards is accomplished by utilization of number 2 fuel oil certified by the vendor that it contains less than 0.5 percent sulfur. Reports documenting fuel use and sulfur content are provided to the EPA Region II office on a quarterly basis.

4.1.5.8 Water Resources

The hydrology information contained herein was extracted from two independent evaluations. One was performed by the U. S. Geological Survey in November 1951. The second survey was performed in 1955. Additional hydrological surveys were performed in 1975 (Moody 1975; DGC 1975), and 1985 and 1986 (DGC 1986).

4.1.5.8.1 Surface Water.

Most of the Site is drained by the Glowegee Creek, which meanders through rolling farmlands and woodlands to a junction with Kayaderosseras Creek at a point approximately 1 mile east of West Milton. The quality of the water in Kayaderosseras Creek and Glowegee Creek is satisfactory for public water supply and most industrial purposes, although Glowegee Creek is not used for these purposes. The average stream flow measured at the U. S. Coast and Geodetic Survey gaging station 0.5 mile downstream of the Site is 41 cfs. The range of elevation for Glowegee Creek is approximately 580 feet above mean sea level at the western entry to the Site to about 380 feet above mean sea level at its junction with the Kayaderosseras Creek. Swamp area and natural surface storage in the basin are small, but the soils and the unconsolidated materials below the soils can hold a considerable volume of groundwater. A number of perennial springs exist in the area. There are no records indicating flooding of the Site.

The Kayaderosseras Creek empties into Saratoga Lake and ultimately, by way of Fish Creek, into the Hudson River. Kayaderosseras Creek rises in the Kayaderosseras Range on the southern edge of the Adirondack Mountains. The basin above West Milton ranges approximately 1600 feet in elevation and contains a sizeable aggregate area of swamps.

The Flood Insurance Rate Map (FIRM COMMUNITY-PANEL No. 360 722 B) shows that the Kesselring Site is not in a 100 or 500 year floodplain.

4.1.5.8.2 Groundwater.

At the Site, the overburden sequence, consisting of glacier and lake deposits, and the underlying Canajoharie Shale generally form poor aquifer systems. In the West Milton area, neither of these systems are designated as sole source aquifers by the EPA or as primary/principal aquifers by New York State.

The dense glacial deposits and fine-grained lake deposits have characteristically low permeabilities in comparison to ice-contact/outwash deposits. Historically, both the glacier and lake deposits produce very low volumes of groundwater. At the Site, shallow water table mapping shows that the groundwater gradient is low. This low gradient combined with the low permeability of the glacial deposits indicates that the groundwater flow rate is very low, on the order of 5 to 10 feet/year. Also, water table mapping indicates that the Glowegee Creek, approximately 200 to 1000 feet east of the operating facilities boundary, forms an aquifer boundary.

The source of potable water is a well field, located on the far eastern side of the Site, and is composed of six wells which draw water from both deep and shallow aquifers. Monitoring of groundwater from the Site service water well field has shown that all chemical constituents measured are within the New York State drinking water standards (KAPL 1992). This well field, which is adjacent to the Kayaderosseras Creek, is underlain by two sand and gravel aquifers. The uppermost aquifer exists under water-table conditions and extends to a depth of approximately 30 feet below ground surface. The lowermost aquifer exists under artesian head pressure with the potentiometric surface rising several feet above the static water-table surface. The depth of the artesian aquifer is approximately 55 to 100 feet below the ground surface. Recharge to the water-table aquifer during simultaneous water withdrawal comes primarily from the Kayaderosseras Creek, and to a lesser degree from Crook Brook. (DGC 1986)

There are 19 monitoring wells within the operating area. These recently installed wells are used to provide depth-to-groundwater information, related water table mapping, and water quality assessment. Test borings on the reservation have generally showed the water table to be within 5 to 10 feet of the ground surface. The test boring data also indicate that the configuration of the water table is, for the most part, a replica of the configuration of the surface topography, but at a lower elevation and somewhat softened in relief.

4.1.5.8.3 Existing Radiological Conditions.

The liquid effluent environmental monitoring program at the Kesselring Site consists of radiological monitoring of the Glowegee Creek water, aquatic life, and sediment in the vicinity of the Site to confirm that the general public is not affected by operations at the Site. There is no detectable radioactivity present in the Glowegee Creek sediment due to Site operations (KAPL 1992). The concentrations of chemical constituents in liquid effluent from the Kesselring Site resulted in no adverse effect on the quality of Glowegee Creek aquatic life. This is substantiated by results of fish and aquatic life surveys that confirmed the existence of a diverse and healthy aquatic community in the creek water. Only naturally occurring radionuclides were detected in the Glowegee Creek water samples. The results of analysis for fish collected from Glowegee Creek show no radioactivity attributable to Site operations.

Currently, Kesselring Site does not discharge radioactive liquid effluent to the environment. Since the beginning of prototype operations, the release of radioactivity into Glowegee Creek has been small (about 15 curies) and has had no measurable effect on the natural background radioactivity in the sediment. Over 98 percent of the radioactivity discharged to the creek was tritium but included traces of other radionuclides such as cobalt-60, iron-55, nickel-63, and antimony-125 (KAPL 1992). The amount of tritium released was greatly decreased when water reuse was started by the prototype plants. In addition, the average concentration of tritium discharged to Glowegee Creek was over 1000 times lower than allowed by federal regulations. In over three decades of operation, there has been no measurable impact from Kesselring Site operations on the environment or adverse effect on the community or the public.

4.1.5.9 Ecological Resources

4.1.5.9.1 Terrestrial Ecology.

The conceptual location where naval spent nuclear fuel would be stored is illustrated in Attachment D. This location is within an existing industrial complex and is surrounded by buildings and paved areas. The industrial nature of the Site and the fact that the land has already been disturbed from its natural state by earlier activities mean that plant or animal species sensitive to disturbance by human activities would not be expected to be present.

4.1.5.9.2 Wetlands.

There are 13 areas located on the Kesselring Site classified as either Class II or III wetlands in accordance with the New York State Department of Environmental Conservation (NYCRR 1987). Current operations which include the secured area of the Site, parking lots, well field, and pumphouse area do not impact the listed wetlands. Access and perimeter roadways abut listed wetlands at four locations (within 100 feet); however, construction of these roadways predates all current regulatory requirements.

4.1.5.9.3 Aquatic Ecology.

In accordance with the Environmental Statement for the S8G Prototype, Kesselring Site, West Milton, New York (USAEC 1972), an expanded chemical and biological monitoring program was initiated in Glowegee Creek early in 1975. An important part of this monitoring program is an annual fish survey in Glowegee Creek upstream and downstream of Site discharges because Glowegee Creek is classified as a Class "C" trout stream by New York State. These surveys conducted by the New York State Department of Environmental Conservation and by environmental consultants from the Knolls Atomic Power Laboratory indicate that stocking downstream merely supplements the fish population that is removed by fishermen. The section of Glowegee Creek above the Site, although not stocked, contains a population of native trout which is maintained by natural spawning of the fish.

4.1.5.9.4 Endangered and Threatened Species.

There are several endangered and threatened species listed by the New York State Department of Environmental Conservation located in the Saratoga County area. The endangered species are the karner blue butterfly, bald eagle, and peregrine falcon, and the threatened species is the red-shouldered hawk. To date, there have been no direct observations of these species documented on the Kesselring Site.

4.1.5.10 Noise

Plant operations and maintenance at the Kesselring Site generate noise equivalent to light industrial activity.

4.1.5.11 Traffic and Transportation

Two corridors, the Hudson-Champlain, 10 to 17 miles to the east, and the Mohawk-Hudson, 10 to 17 miles to the south and southwest, contain the major transportation systems and the relevant industrial complexes in the vicinity of the Site. The Cottrell Paper Company, located in Rock City Falls, 3 miles from the Site, is the only industry within a 5-mile radius.

Except for their use by Kesselring Site employees, the secondary routes bounding the Site are auxiliary commuting and delivery routes for small products and produce. State Route 29 runs 2 miles to the north, State Route 147 runs 4 miles to the west, and State Route 67 runs 4 miles to the south. State Route 50, 6 miles east, running from Saratoga Springs to Scotia, carries the only appreciable amount of truck and bus traffic. The majority of through traffic uses either Interstate I-87 or parallel route U.S. Highway 9, in the Hudson-Champlain corridor, 10 miles to the east.

Two lines of the Delaware and Hudson Railroad cross the region within 10 miles of the Site. The main north-south line runs through Ballston Spa, just over 5 miles to the east, and a trunkline runs just over 5 miles to the northeast into the central Adirondack area.

Commercial barge traffic occurs on the New York State Barge Canal, 12 miles southwest of the Site at its closest point, and on the less used Champlain Division, 17 miles east of the Site.

Saratoga County has the nearest airport, 4-1/2 miles east of the Site, followed by

Schenectady and Albany airports, approximately 15 and 20 miles to the south-southeast. Data furnished by air traffic representatives for the three area airports indicate that regular flight patterns for military, commercial, and private aircraft, large and small, do not pass within a 5-mile radius of the Site. Only the instrument approach to the Saratoga County Airport, designated by the Federal Aviation Administration (FAA), has the potential for overflying the Site.

Albany County Airport, 22 miles south-southeast of the Site, is the nearest airport with scheduled flights by commercial jet aircraft. Schenectady County Airport, 15 miles south of the Site, is an auxiliary field with a low volume of traffic relative to size. No air carriers provide scheduled service out of Schenectady. The bulk of the airport's traffic is corporate and private aircraft, with the majority of the balance being military aircraft of the 109th New York Air National Guard.

Naval spent nuclear fuel has been removed from the prototypes and transported to the Idaho National Engineering Laboratory Expended Core Facility (ECF) for examination and evaluation as a matter of routine. Naval spent nuclear fuel shipments from the Kesselring Site to ECF were initiated in 1961. Since that time, 21 shipments of naval spent nuclear fuel originating at the Kesselring Site have been made to ECF. The shipping containers were transported by heavy-lift transporter to a nearby commercial rail line where the containers were then transported by rail. Attachment A provides a list of these shipments made to date by year. Attachment A also contains detailed descriptions of the shipping containers used for naval spent nuclear fuel shipments from shipyards.

The Site exclusion area boundary, which is the boundary of the Site, defines the restricted area. No activities unrelated to plant operation are permitted within the exclusion area. Access to the fenced-in security area containing the operating facilities (centered within the exclusion area boundary) is permitted only through one permanent gate facility which is manned by security guards on a 24-hour-per-day basis.

No public roads, highways, railways, or navigable waterways traverse the exclusion area.

4.1.5.12 Occupational and Public Health and Safety

4.1.5.12.1 Occupational Radiological Health and Safety. The Navy has well established and

effective Occupational Safety, Health, and Occupational Medicine programs at all of its facilities. In regard to radiological aspects of these programs, the Naval Nuclear Propulsion Program policy is to reduce to as low as reasonably achievable the external exposure to personnel from ionizing radiation associated with naval nuclear propulsion plants. These stringent controls on minimizing occupational radiation exposure have been successful. No personnel at the Naval Reactors Department of Energy facilities have ever exceeded the applicable federal annual radiation exposure limit. The annual limit was 15 rem per year in 1958 and is currently 5 rem per year. No one has exceeded the Program's limit of 5 rem per year since this limit was established in 1967 and since 1980, no one has received more than 2 rem per year from radiation associated with naval nuclear propulsion plants. The average occupational exposure of each person monitored at Naval Reactors DOE facilities is 0.12 rem per year. The average lifetime accumulated radiation exposure from radiation associated with the Naval Nuclear Propulsion Program for the 141,000 personnel who have been monitored at the DOE Naval Reactors facilities is about 0.35 rem (NNPP 1994c). This corresponds to the likelihood of a cancer fatality of 1 in 7142.

Naval Reactors policy on occupational exposure from ingested or inhaled radioactivity is to prevent significant radiation exposure to personnel from internal radioactivity. The limits invoked to achieve this objective are one-tenth of the levels allowed by federal regulations for radiation workers. Since 1972 as a result of this policy, no one has received more than one-tenth the federal annual occupational exposure limit from internal radiation exposure caused by radioactivity associated with work at the DOE Naval Reactors facilities.

For work operations involving the potential for spreading radioactive contamination, containments are used to prevent personnel contamination or generation of airborne radioactivity. The controls for contamination are so strict that precautions sometimes have had to be taken to prevent tracking contamination from fallout and natural sources into radiological areas because the contamination control limits used in these areas were well below the levels of fallout and natural contamination occurring outside in the general public areas. A basic requirement of contamination control is monitoring all personnel leaving any area where radioactive contamination could possibly occur. Workers are trained to survey themselves (i.e., frisk), and their performance is checked by radiological control personnel. Frisking of the entire body is required, normally using sensitive hand-held survey instruments. Major work facilities are equipped with portable monitors, which are used in lieu of hand-held friskers. These stringent controls to protect the workers and the public from contamination have proven effective in the past.

In 1991, researchers from Johns Hopkins University, Baltimore, Maryland, completed a very comprehensive epidemiological study of the health of workers at the six naval shipyards and two private shipyards that service the Navy's nuclear-powered ships (Matanoski 1991). This independent study evaluated a population of 70,730 civilian workers over a period from 1957, beginning with the first overhaul of the first nuclear-powered submarine, USS NAUTILUS, through 1981, to determine whether there was an excess risk of leukemia or other cancers associated with exposure to low levels of gamma radiation. This study is also of particular relevance to workers at the Naval Reactors prototypes because the type of radioactivity, level of exposure, and method of radiological controls at these shipyards are similar to the Naval Reactors prototypes.

The Johns Hopkins study found no evidence to conclude that the health of people involved in work on U.S. naval nuclear-powered ships has been adversely affected by exposure to low levels of radiation incidental to this work. The average annual radiation exposure for these shipyard workers is about two times higher than the exposure received by personnel assigned to Naval Reactors nuclear propulsion prototype sites. Additional studies are planned to investigate the observations and update the shipyard study with data beyond 1981.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. The radiation exposure to transportation workers for all historical shipments is 16.6 person-rem, which statistically corresponds to 0.0066 cancer fatalities. The maximum exposed individual (MEI) is a transportation worker, since the workers are closer to the shipment for a longer time than any member of the general population.
Under the limiting assumption that the same worker is associated with every shipment for the entire historical period, this person would receive a total exposure of 7.5 rem over the approximately 40-year period, or about 0.19 rem per year, which is within DOE standards for occupationally exposed individuals. The radiation exposures to workers correspond to much less than one incident cancer, which means that it is unlikely that there have been any past health impacts due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.5.12.2 Occupational Non-radiological Health and Safety.

In the non-radiological Occupational Safety, Health and Occupational Medicine area, the Navy complies with the Occupational Safety and Health Administration Regulations. The Navy's policy is to maintain a safe and healthful work environment at all naval facilities. Engineered systems and administrative controls are the primary means employed for minimizing potential employee exposure to occupational hazards. If exposures cannot be controlled with engineering or administrative controls, personal protective equipment is used to provide additional protection. Due to the varied nature of work at these facilities, there is a potential for certain employees to be exposed to physical and chemical hazards.
These employees are routinely monitored during work and receive medical surveillance for physical hazards such as exposure to high noise levels or heat stress. In addition, employees are monitored for their exposure to chemical hazards such as organic solvents, lead, asbestos, etc., and where appropriate are placed into medical surveillance programs for these chemical hazards.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. Approximately 0.028 fatalities are estimated as a result of non-radiological sources (vehicle emissions) associated with all historical shipments of spent nuclear fuel. This number includes both the workers and the general public. Since this number is much less than one, it is unlikely that there has been any non-radiological health impact due to the historical shipment of naval spent nuclear fuel over the entire history of such shipments.

4.1.5.12.3 Public Radiological Health and Safety.

The effluent and environmental monitoring results show that the radioactivity in liquid and gaseous effluents from 1992 operations at the Kesselring Site had no measurable effect on background radioactivity levels. Therefore, any radiation exposures from Site operations to off-site individuals were too small to be measured and must be calculated using conservative methods. In accordance with the "Knolls Atomic Power Laboratory Environmental Monitoring Report for Calendar Year 1992" (KAPL 1992), the following estimates were determined: (1) the radiation exposure to the maximally exposed individual in the vicinity of the Site was less than 0.1 mrem, (2) the average exposure to members of the public residing in the 80-kilometer (50-mile) radius assessment area surrounding the Site was less than 0.001 mrem, and (3) the collective exposure to the population residing within 50 miles of the Site was less than 0.1 person-rem.

The hypothetical exposures calculated in Attachment F for the period 1995 through 2035 were adjusted from an annual basis (1995) to the historical basis by multiplying by 40 years (to account for the period of site operations) and by a factor of 1.7 to take into consideration variations in the number of prototypes and operations.

The calculated accumulated exposures through 1995 to the general population within 50 miles of the site (about 1.15 million people) are 3.9 person-rem. To provide perspective, the exposures received due to natural radiation sources through 1995 are approximately 14 million person-rem, based on 0.3 rem per person per year.

The results show that the estimated exposures were less than 0.1 percent of that permitted by the radiation protection standards listed in DOE Order 5400.5 (DOE 1993), and that the estimated exposure to the population residing within 80 kilometers (50 miles) of the Site was less than 0.001 percent of the natural background radiation exposure to the population. In addition, the estimated exposures were less than 1 percent of that permitted by the numerical guide listed in 10CFR50, Appendix I (CFR 1986) for whole-body exposure, demonstrating that exposures are as low as is reasonably achievable. The exposure attributed to radioactive air emissions was less than 1 percent of the EPA standard given in 40CFR61 (CFR 1989).

The collective radiation exposure to the public along travel routes from Kesselring Site shipments of radioactive materials during 1992 was calculated using data given by the NRC in the "Final Environmental Statement of the Transportation of Material by Air and Other Modes" (NUREG 1977). Based on the type and number of shipments made, the collective annual radiation exposure to the public along the transportation routes, including transportation workers, was approximately 1 person-rem. This is less than 0.001 percent of the exposure received by the same population from natural background radiation.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. The radiation exposure to the general population for all historical shipments is 1.95 person-rem, which statistically corresponds to 0.00098 cancer fatalities.

All of the radiation exposures to the general population correspond to much less than one incident cancer, which means that it is unlikely that there has been any past health impact to the public due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.5.12.4 Public Non-radiological Health and Safety.

Liquid effluents from the Kesselring Site are derived from several sources: Site boiler blowdown, sewage treatment plant, cooling tower blowdown and overflow, retention basin discharges, storm water, and site service cooling water. Liquid effluents from the Kesselring Site enter Glowegee Creek through two surface channels (discharges 001 and 002), a submerged drain line from the sewage treatment plant (discharge 003), and a storm water runoff (discharge 004).

With the exception of the sewage treatment plant, intermittent cooling tower blowdowns, and once-through cooling systems that operate continuously, all effluents are released in batches. Control of effluent concentrations is achieved by the analysis of liquid collected from the continuous flow systems and from the collection tanks prior to each release from the batch systems.

A series of gates are located in discharge channels 001, 002, and the lagoon to provide a means to contain effluent if concentrations should ever exceed applicable discharge limits. In addition, continuous pH and temperature monitoring systems are installed in discharge channels 001, 002, and the lagoon. These systems automatically control the discharge gates and provide an alarm if there is ever an out-of-specification pH or temperature level. Periodic samples collected from the effluent channels are analyzed for chemical constituents, and demonstrate compliance with the Site's New York State Department of Environmental Conservation State Pollutant Discharge Elimination System permit.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. Approximately 0.028 fatalities are estimated as a result of non-radiological sources (vehicle emissions) associated with all historical shipments of spent nuclear fuel. This number includes both the workers and the general public. Since this number is much less than one, it is unlikely that there has been any non-radiological health impact to the public due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.5.13 Utilities and Energy

4.1.5.13.1 Water Consumption. The Site Service Water System provides the Kesselring Site

with water for operations, fire protection, sanitary, and potable use. The Site uses approximately 512 million gallons of well water per year. The Site is supplied by two pressurized mains from pumps located at the well field. Main and backup chlorination facilities are located at two of the pump locations. Five loops, on site, comprise the central distribution system which is capable of delivering up to 3,800 gallons per minute. Surge capacity for fire fighting and peak usage is provided by two elevated head tanks with a combined capacity of 500,000 gallons.

4.1.5.13.2 Electricity Consumption.

The Kesselring Site is provided with two separate off-site commercial electrical power sources from the Niagara Mohawk Power Company. One source is the 115-kv Transmission Line No. 1 that runs between Spier Falls, New York and Rotterdam, New York. This line is approximately 40 miles long and is tapped at approximately the midpoint to provide service to the Site. The overhead line from the 115-kv tap on Line No. 1 to the Site is 2.4 miles long. The second physically independent commercial source feeding the Site is a 34.5-kv overhead transmission line supplied from a radial system fed from Ballston Spa, New York. The 34.5-kv line is approximately 9.6 miles long. The Site uses 47 thousand megawatt-hours of electricity annually for security, building lighting, and prototype plant support.

4.1.5.13.3 Fuel Consumption.

There is no natural gas used on the Kesselring Site. Number 2 fuel oil is used to fire four Site steam generating boilers for Site heating for which the annual fuel oil consumption averages 640,000 gallons.

4.1.5.13.4 Wastewater Systems and Discharges.

The sewage treatment facility for the Kesselring Site is a third-level treatment facility utilizing the extended aeration/contact stabilization of activated sludge and chemical precipitation of phosphorus followed by sand filtration. This facility meets all federal and New York State standards for sewage treatment. Discharges are controlled in conformance with the terms of a New York State Pollutant Discharge Elimination permit. Waste sludge is stored in a holding tank and is periodically removed by a licensed subcontractor for disposal at a state-approved, off-site disposal area. The treatment plant is automatic and operates unattended. Routine analysis and adjustments are made daily. Approximately 9.125 million gallons of sewage are processed by the Site Sewage Treatment Facility each year.

4.1.5.13.5 Energy Consumption.

The following energy conservation initiatives for the Kesselring Site are scheduled for completion between now and the year 2000:

(1) The shutdown of one prototype plant.
(2) The conversion from fuel oil to natural gas for operating the Site steam heating boilers.
(3) Replacing the existing building lights and windows with modern, more energy efficient systems.
(4) Major building renovations including energy conservation upgrades to various administration and testing facilities.

4.1.5.14 Materials and Waste Management

Operation of the Kesselring Site results in the generation of various types of radioactive materials that require detailed procedures for handling, packaging, transportation, and, if necessary, disposal at a government-operated burial site. Radioactive materials that do not require disposal are handled and transferred in accordance with detailed material control and accountability procedures. Internal reviews are made prior to the shipment of any radioactive materials from the Site to ensure that the material is properly identified, surveyed, and packaged in accordance with federal, state, and local requirements.

Low-level radioactive solid waste material that requires disposal includes filters, metal scrap, resin, rags, paper, and plastic. The volume of waste contaminated with radioactivity that is generated and shipped is minimized through the use of special work procedures that limit the amount of material that becomes contaminated during work on radioactive systems and reactor components. In addition, compressible wastes are compacted in order to further reduce the volume of waste to be buried. Radioactive liquids are solidified prior to shipment. All radioactive wastes are packaged to meet applicable regulations of the Department of Transportation given in 49CFR, Parts 171-175 and 177-178 (CFR 1985). The waste packages also comply with all applicable requirements of the NRC, the DOE, and the burial sites. All shipments of low-level radioactive solid wastes were made by authorized common carriers to government-owned burial sites located outside of New York State. During 1992, approximately 215 cubic meters (281 cubic yards) of routine low-level radioactive waste containing 987 curies were shipped from the Site for burial.

Site operations produce a variety of industrial waste products including sewage treatment plant sludge and effluent, once-through cooling water, chemical wastes, boiler exhaust gases, and other such products typical of a large laboratory facility. All such waste products are controlled in accordance with various permits as required by federal and state laws. Chemically hazardous solids are controlled and disposed of in accordance with the requirements of the Resource Conservation and Recovery Act (RCRA) in accordance with a permit held by the Site and administered by New York State.

All hazardous wastes are transported off-site for disposal at permitted, commercially available, facilities. No treatment (with the exception of exempt simple treatment and elementary neutralization) or disposal occurs at the Kesselring Site. In 1992, the Kesselring Site shipped approximately 15 tons of various hazardous wastes for off-site disposal. In accordance with RCRA, the Site has prepared a hazardous waste minimization plan. The plan requires specific actions to identify and minimize waste-producing operations, compare minimization efforts year to year to demonstrate progress, and establish waste minimization goals. This is accomplished by establishment of strict procurement procedures, substitution of non-hazardous materials where practical, and other similar measures.

Waste which is both radioactive and chemically hazardous is regulated under both the Atomic Energy Act and the RCRA as "mixed waste." Within the Naval Nuclear Propulsion Program, concerted efforts are taken to avoid commingling radioactive and chemically hazardous substances so as to minimize the potential for generation of mixed waste. For example, these efforts include avoiding the use of acetone solvents, lead-based paints, lead shielding in disposal containers, and chemical paint removers. Radioactive wastes, including those containing chemically hazardous substances, are handled in accordance with long-standing Program radiological requirements. Such handling includes solidification to immobilize the radioactivity, separation of the radioactive and chemically hazardous substances, removal of liquids from solids, and other simple techniques. A determination is then made as to whether the resulting waste is hazardous. As a result of Program efforts to avoid the use of chemically hazardous substances in radiological work, Program activities typically generate only a few hundred cubic feet of mixed waste each year. This small amount of mixed waste, along with limited amounts of mixed waste from Program work conducted prior to 1987, will be stored pending the licensing of commercial treatment and disposal facilities.

Sanitary wastewater is processed at a conventional extended aeration treatment plant at the southeast corner of the fenced security area. The treatment train consists of equipment to break down large solids, aeration tanks in which air is bubbled through the waste to provide mixing with activated sludge to reduce biochemical oxygen demand, and a clarifier for the separation of liquids and solids. The treatment plant is effective in reducing biochemical oxygen demand and suspended solids by over 90 percent in the effluent. Discharges are controlled in conformance with the terms of a New York State Pollutant Discharge Elimination System permit held by the Kesselring Site. As the need arises, accumulated sludge is removed from the plant by a New York State licensed subcontractor and disposed of at an approved off-site disposal facility also licensed by New York State.

Non-hazardous wastes are reused and recycled or disposed of off-site. Sanitary wastes such as cafeteria waste, scrap paper, and the like are also disposed of at a licensed off-site facility. No hazardous wastes are being buried in the landfill. Most metal solid waste is accumulated and sold to a scrap salvage vendor.

4.2 IDAHO NATIONAL ENGINEERING LABORATORY

4.2.1 Overview

There are three naval reactor prototype plants at the Idaho National Engineering Laboratory (INEL) at the Naval Reactors Facility (NRF). These plants contain nuclear reactor plants, but they have reached the end of their usefulness and are being placed in layup and safe storage. Dismantlement of each of the prototype plants will be accomplished in the future; however, no specific time has yet been set for this work. Appropriate documentation under the National Environmental Policy Act (NEPA) will be prepared for prototype dismantlement when a specific proposal for these actions has been developed.

Also located at the Naval Reactors Facility is the Expended Core Facility (ECF) to which naval spent nuclear fuel has been shipped for examination since 1957. After examination at the ECF, the spent nuclear fuel is transferred to the Idaho Chemical Processing Plant, also at INEL, for storage. This section provides a brief summary of the INEL affected environment. A detailed description of the affected environment at the INEL is provided in Volume 1, Appendix B and Volume 2, Section 4. The reader should refer to the applicable sections therein for additional information.

4.2.2 Land Use

The INEL site (which has been designated a National Environmental Research Park) occupies approximately 2300 square kilometers (about 890 square miles) of dry, cool desert in southeastern Idaho. Land at the INEL site is currently used for industrial and support operations associated with energy research and waste management activities, grazing, infrastructure, recreational uses, and environmental research. Only about 2 percent of the land is used for facilities and operations. Public access to most facility areas is restricted. Land surrounding the INEL site is primarily used for grazing, mineral and energy production, wildlife management, range land, and recreational uses.

4.2.3 Socioeconomics

INEL plays a substantial role in the regional economy. For fiscal year 1990, INEL directly employed approximately 11,100 personnel, or nearly 12 percent of the total regional employment. The population directly supported by INEL employment was approximately 38,000 persons, or 17 percent of the total regional population. Over 97 percent of INEL employees reside in the region of influence affected by the INEL. The INEL region of influence includes the seven counties surrounding and including the INEL: Bingham, Bonneville, Butte, Clark, Jefferson, Bannock, and Madison counties. Employment in this region experienced an annual average growth rate of approximately 1.3 percent from 1980 to 1991 while the population growth in the same region between 1980 and 1990 was about 0.6 percent per year. Volume 1, Appendix B provides a complete description of the affected environment at the INEL in this category.

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," requires federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs and activities on minority and low-income populations. An adverse environmental impact is a deleterious environmental impact determined to be unacceptable or above generally accepted norms. A disproportionately high impact refers to an impact (or risk of an impact) in a low-income or minority community that significantly exceeds that on the larger community. Data available from the U. S. Census of 1990 have been used to develop information on the locations of minority and low-income populations within approximately 50 miles of the INEL, and are provided in Appendix B to this volume of the Environmental Impact Statement. These data were developed in a manner which ensures that they are consistent with the data on the total population provided in Appendix B.

4.2.4 Cultural Resources

Approximately 4 percent of the INEL has been surveyed for archaeological resources. Over 1500 sites have been identified; however, none are currently on the National Register of Historic Places, but may be placed there after formal evaluation. One structure on the INEL related to nuclear research and development, the Experimental Breeder Reactor I, is on the National Register of Historic Places and is a National Historic Landmark while a number of other reactors and associated buildings are eligible for inclusion. The entire INEL site is culturally important to Native Americans, since they believe the land is sacred. Further information on cultural resources at INEL is provided in Volume 1, Appendix B, Section 4.4 and in Volume 2, Section 4.4.2.

4.2.5 Aesthetic and Scenic Resources

The INEL site is bordered on the north and west by the Bitterroot, Lemhi, and Lost River mountain ranges. Volcanic buttes near the southern boundary of the INEL can be seen from most locations on the site. Most of the area within the INEL site consists of open, undeveloped land. Although many of the site facilities are visible to the public, most facilities are located over 0.5 mile from public roads. The reader should refer to the detailed description of the affected environment in this category at the INEL in Volume 1, Appendix B.

4.2.6 Geology

The INEL site is located on the Eastern Snake River Plain which extends in a broad arc from the Idaho-Oregon border in the west to the Yellowstone Plateau in the east. The resources found within the site are sand, gravel, and pumice.

The Eastern Snake River Plain has low seismicity but is surrounded by an area of high seismicity. A summary of the seismicity at the ECF site is provided in Attachment B.

Volcanic hazards at the INEL site have a low probability of occurrence. Volcanism hazards in the INEL area consist of possible recurrence of silicic volcanism, silicic dome emplacement, and basaltic eruptions. Of these three volcanic hazards, basaltic eruptions have been determined to have the highest expectation of occurrence. The potential for basaltic volcanism that could affect ECF is less than 10-5 per year. The reason that the risk from volcanic hazards at ECF is so low is that the facility is more than 9 miles north of the highest potential source of basaltic eruptions. Because of the viscous nature of basaltic lava flows, they are very slow moving and can be diverted in terrain such as that on the INEL. The potential for silicic volcanism impacting ECF is negligible because the center of silicic volcanism is now located under Yellowstone National Park which is about 125 miles east of ECF. Several small silicic domes were emplaced in the vicinity of INEL in the past 1.5 million years. These silicic domes are about 17 miles south of the Expended Core Facility and would have minimal impact on the site. (Rizzo 1994)

4.2.7 Air Resources

The Eastern Snake River Plain climate exhibits low relative humidity, wide daily temperature swings, and large variations in annual precipitation. The average seasonal temperatures at the INEL site range from -7.3 degrees C (18.8 degrees F) in winter to 18.2 degrees C (64.8 degrees F) in summer. Annual precipitation is light, averaging 22.1 centimeters (8.7 inches). The average annual snowfall is 70.1 centimeters (27.6 inches). Other than thunderstorms, severe weather is uncommon.

The air quality on the INEL site and off-site is generally good and within applicable guidelines. Details of the non-radiological air quality and the radiological air quality are provided in Appendix B of Volume 1.

4.2.8 Water Resources

Surface water features near the INEL site are the Big Lost River, Little Lost River, Birch Creek, and on-site man-made ponds. Water in the rivers does not exceed the applicable drinking water quality standards. The potential for flooding has been assessed. Details on the INEL flood plains can be found in Appendix B and Volume 2.

Groundwater in the area is contained in the Snake River Plain Aquifer. Subsurface water quality is affected by natural water chemistry and contaminants originating at the site. Previous waste discharges to unlined ponds and deep wells have introduced radionuclides, non-radioactive metals, inorganic salts, and organic compounds into the subsurface water. For a complete description of the affected environment in this category, the reader should refer to Volume 1, Appendix B.

4.2.9 Ecological Resources

Vegetation on the INEL site is primarily shrub-steppe vegetation, with sagebrush being the dominant plant. The INEL supports animal communities typical of shrub-steppe vegetation and habitats. Over 270 vertebrate species have been observed on the site. A more thorough treatment of the topic of ecological resources at the INEL is provided in Volume 1, Appendix B. Also presented therein is a description of the threatened and endangered species which include the bald eagle and the peregrine falcon.

4.2.10 Noise

The major sources of noise at the INEL occur primarily in developed operational areas and include various facilities, equipment, and machines. Existing INEL-related noises which might affect the public are those from transporting people and materials to and from the INEL and in-town facilities via buses, trucks, private vehicles, helicopters, and freight trains. In addition, air cargo and business travel of INEL personnel via commercial air transport represent an appreciable fraction of all such travel in and out of regional airports.

4.2.11 Traffic and Transportation

The INEL is surrounded by a system of interstate highways, U.S. highways, state highways, railroads, and airports. The regional railroads include main and branch Union Pacific lines in Southeastern Idaho. The two major airports in Idaho Falls and Pocatello provide passenger and cargo service.

The INEL transportation infrastructure consists of an on-site road system and rail service. There are about 140 kilometers (87 miles) of paved roads, of which 29 kilometers (18 miles) are considered service roads and are closed to the public. The Union Pacific Railroad crosses the southern portion of the INEL and provides rail service to the site. Rail shipments are limited to bulk commodities, spent nuclear fuel, and radioactive materials.

4.2.12 Occupational and Public Health and Safety

4.2.12.1 Occupational Radiological Health and Safety. Radiation exposures to workers at

ECF in recent years have averaged approximately 100 millirem per year, compared to the limit of 5000 millirem per year specified by The Code of Federal Regulations, Title 10, Part 20. The total radiation exposure to workers at ECF makes up about 30% of the occupational exposure to radiation experienced by workers at NRF. Approximately 280 workers at ECF work in radiological areas and are monitored for occupational radiation exposure. The average lifetime accumulated radiation exposure from radiation associated with naval nuclear propulsion plants for the 141,000 personnel who have been monitored at the DOE Naval Reactors facilities including ECF, is about 0.35 rem (NNPP 1994c). This corresponds to the likelihood of a cancer fatality of 1 in 7142.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. The radiation exposure to transportation workers for all historical shipments is 16.6 person-rem, which statistically corresponds to 0.0066 cancer fatalities. The maximum exposed individual (MEI) is a transportation worker, since the workers are closer to the shipment for a longer time than any member of the general population.
Under the limiting assumption that the same worker is associated with every shipment for the entire historical period, this person would receive a total exposure of 7.5 rem over the approximately 40-year period, or about 0.19 rem per year, which is within Department of Energy (DOE) standards for occupationally exposed individuals. The radiation exposures to workers correspond to much less than one incident cancer, which means that it is unlikely that there have been any past health impacts due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.2.12.2 Occupational Non-radiological Health and Safety. In the non-radiological Occupational Safety, Health, and Occupational Medicine area, the Navy complies with the Occupational Safety and Health Administration Regulations. The Navy's policy is to maintain a safe and healthful work environment at all naval facilities. Due to the varied nature of work at these facilities, there is a potential for certain employees to be exposed to physical and chemical hazards. These employees are routinely monitored during work and receive medical surveillance for physical hazards such as exposure to high noise levels or heat stress. In addition, employees are monitored for their exposure to chemical hazards such as organic solvents, lead, asbestos, etc., and where appropriate are placed into medical surveillance programs for these chemical hazards.

Operations at ECF have resulted in fewer than 210 days of work lost to injuries in the seven years between 1987 and 1993 out of 736 total lost days of work at NRF during that period. Recordable injuries at ECF represented about 12 percent of the total number of such injuries at NRF during the same period.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. Approximately 0.028 fatalities are estimated as a result of non-radiological sources (vehicle emissions) associated with all historical shipments of spent nuclear fuel. This number includes both the workers and the general public. Since this number is much less than one, it is unlikely that there has been any non-radiological health impact due to the historical shipment of naval spent nuclear fuel over the entire history of such shipments.

Limited quantities of some materials classified as hazardous chemicals are handled at ECF, but the precautions used during the work prevent exposure of the workers to these materials.

4.2.12.3 Public Radiological Health and Safety. The Naval Reactors Facility has from its beginning monitored potential sources of releases of radioactivity to the environment from the NRF site in liquid and airborne effluents. Releases of water containing low levels of radioactivity to various disposal basins, leaching pits, and retention basins were made principally in the 1950s and 1960s. This practice was discontinued in 1979 and the residual activity in the soil from this practice is estimated to be approximately 150 curies, consisting primarily of cesium-137, strontium-90, and cobalt-60. The Naval Reactors Facility maintains a program to monitor these areas to provide assurance that they continue to not present a hazard to the public. Operations at NRF, including ECF, have had no effect on the groundwater of the Snake River Plain Aquifer. Monitoring of the aquifer on the NRF site indicates radioactivity is at or near natural background levels. The comprehensive INEL site radiation monitoring program (Hoff et al. 1992) shows that radiation exposure to persons off-site as a result of all NRF operations is too small to be measured.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. The radiation exposure to the general population for all historical shipments is 1.95 person-rem, which statistically corresponds to 0.00098 cancer fatalities. The maximum exposed individual (MEI) is a transportation worker, since these workers are closer to the shipment for a longer time than any member of the general population. The maximum exposure to an individual of the general population is 0.062 rem over the entire historical period, which statistically corresponds to 0.000031 cancer fatalities.

4.2.12.4 Public Non-radiological Health and Safety. Since operations began, NRF has monitored site water and air released from operations at the site to ensure that they meet the requirements of applicable federal and state environmental standards. Results of all effluent monitoring confirm that the operation of NRF has no discernible impact on the environment (WECNRF 1993). Operations at NRF have not caused degradation of the quality of the groundwater of the Snake River Plain Aquifer. Monitoring results indicate no detectable toxic chemicals, solvents, or laboratory chemicals in the groundwater in the vicinity of NRF. Low levels of sodium and chloride (like table salt) used to soften site water and nitrates (which leaked through cracks in the sewage lagoon liners) and discharges to the industrial waste ditch are detectable in the immediate vicinity of NRF at levels below the applicable drinking water standards. No constituent measured in groundwater exceeds applicable drinking water standards.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. As stated in Section 4.2.12.2, it is unlikely that there has been any non-radiological health impact to the public due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.2.13 Utilities and Energy

The following discussion briefly describes the current utility and energy usage at INEL. For more detailed information, refer to Volume 1, Appendix B.

Commercial electrical power is supplied to the INEL site by the Idaho Power Company. The water supply for INEL is provided by a system of wells, pumps, and storage tanks which are administered by the DOE. Because of the distance between site facility areas, the water supply systems for each facility are independent of each other. Wastewater systems at most on-site facility areas consist primarily of septic tanks and drain fields, although two areas also have wastewater treatment facilities. The fuels consumed at the site (fuel oil, gasoline, diesel, kerosene, coal, and liquid petroleum gas) are transported to the site by various distributors for storage and use.

4.2.14 Materials and Waste Management

The following discussion briefly describes the current waste disposal practices at the INEL. For more detailed information, refer to Volume 1, Appendix B.

High-level waste is currently in storage at the INEL Idaho Chemical Processing Plant. Liquid waste is blended and then treated by calcination to produce a granular calcine solid.

Transuranic waste is kept in retrievable storage at the Radioactive Waste Management Complex. Although there is no currently available disposal facility, all transuranic wastes are intended to ultimately be retrieved, repackaged, certified, and shipped to the Waste Isolation Pilot Plant for final disposal.

Low-level waste has been stored and disposed of at the Radioactive Waste Management Complex. Most low-level waste is reduced in volume before disposal through incineration, compaction, and sizing at the Waste Experimental Reduction Facility; however, this treatment has been curtailed since 1991 awaiting an operating permit from the State of Idaho. Low-level waste awaiting treatment is stored on asphalt/concrete pads at the Waste Experimental Reduction Facility and in radioactive waste storage containers at the generating facilities.

Most of the mixed low-level waste currently stored at the INEL is alpha-contaminated low-level mixed waste shipped to the INEL for storage and treatment from off-site generators. Currently, only low-level mixed waste from INEL contractors is accepted at INEL for treatment and disposal. All low-level mixed waste generated at INEL is stored at interim storage facilities until treatment systems become available or operational.

Hazardous waste generated at the INEL is not treated or permanently stored at the INEL. It is collected and temporarily stored at the Hazardous Waste Storage Facility, or at temporary accumulation areas, and shipped off-site to permitted treatment, storage, or disposal facilities.

The industrial/commercial solid waste generated at the INEL is disposed of in the INEL Landfill Complex located at the Central Facilities Area. Waste segregation takes place at each INEL facility so recyclable materials do not enter the solid waste stream.

4.3 SAVANNAH RIVER SITE

4.3.1 Overview

As mentioned previously, naval spent nuclear fuel has been shipped to the Expended Core Facility (ECF) at the Idaho National Engineering Laboratory (INEL) for examination since 1957. One of the alternatives under consideration is to create a facility similar to ECF at or adjacent to the DOE-owned Savannah River Site (SRS) in South Carolina. A detailed description of the environment at the SRS is provided in Volume 1, Appendix C. This section provides a summary of some of the highlights from Volume 1, Appendix C. Therefore, specific source references for information contained in this section are omitted here but can be found in Volume 1, Appendix C.

Two sites have been identified as possible locations for the construction of a full-capability Expended Core Facility. One location for the Savannah River ECF is just to the east of the geographic center of the complex (see Site A on Figure 4.3-1). The other location (Site B) is the unused Barnwell Nuclear Fuel Plant located just outside of the eastern boundary of the present SRS complex. In either case, a separate security area would be established specifically to enclose the Savannah River ECF, with all access controlled by the Naval Reactors Program as has always been the case at the INEL-ECF.

4.3.2 Land Use

The SRS (which has been designated a National Environmental Research Park) occupies an area of approximately 800 square kilometers (310 square miles) in western South Carolina in a generally rural area about 40 kilometers (25 miles) southeast of Augusta, Georgia. Land use on the Savannah River Site can be grouped into three major categories: forest/undeveloped, water/wetlands, and developed facilities. Land use bordering SRS is primarily forest and agricultural. There is also a large amount of open water and non-forested wetlands along the Savannah River Valley. The SRS does not contain any public recreation facilities and only about 5 percent of the land is occupied by constructed facilities.

Figure 4.3-1. Candidate sites for an Expended Core Facility.

4.3.3 Socioeconomics

Approximately 90 percent of the SRS work force lives within the region of influence affected by the SRS. The SRS region of influence includes Aiken, Allendale, Bamberg, and Barnwell Counties in South Carolina, and Columbia and Richmond Counties in Georgia. Employment in this region experienced an annual average growth rate of approximately 5 percent between 1980 and 1990. Over this same time period, the labor force in the six-county region of influence grew approximately 39 percent. Personal income in the region of influence is about $7 billion. Population in the region of influence increased 13 percent from 376,058 in 1980 to 425,607 in 1990. Appendix C of Volume 1 provides a complete description of the affected environment at the SRS in this category.

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," requires federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs and activities on minority and low-income populations. An adverse environmental impact is a deleterious environmental impact determined to be unacceptable or above generally accepted norms. A disproportionately high impact refers to an impact (or risk of an impact) in a low-income or minority community that significantly exceeds that on the larger community. Data available from the U. S. Census of 1990 have been used to develop information on the locations of minority and low-income populations within approximately 50 miles of the SRS, and are provided in Appendix C to this volume of the Environmental Impact Statement. These data were developed in a manner which ensures that they are consistent with the data on the total population provided in Appendix C.

4.3.4 Cultural Resources

Cultural resources on the SRS can be summarized by stating that approximately 60 percent of the SRS area has been examined by the South Carolina Institute of Archaeology, University of South Carolina, in consultation with the South Carolina State Historic Preservation Officer, and more than 850 archaeological sites have been identified. These range in age from Clovis Paleoindian to 1950s farms. Most structures were demolished during initial establishment of the SRS. Appendix C of Volume 1 provides a complete description of the affected environment at the SRS in this category.

4.3.5 Aesthetic and Scenic Resources

The dominant aesthetic setting in the vicinity of the SRS consists mainly of agricultural land and forest, with some limited residential and industrial areas. Because of the distance to the site boundary, the rolling terrain, normally hazy atmospheric conditions, and heavy vegetation, SRS facilities are not generally visible from off the Site. The land on the SRS is heavily wooded, and developed areas occupy only approximately 5 percent of the total land area.

4.3.6 Geology

The SRS is on the Upper Atlantic Coastal Plain of South Carolina, which consists of approximately 200 to 400 meters of sands, clays, and limestones formed millions of years ago. These sediments are underlain by sandstones of Triassic age and older metamorphic and igneous rocks.

There are no known capable faults as defined by the Nuclear Regulatory Commission regulatory guidelines in the SRS region. Therefore, earthquakes capable of producing structural damage are not likely in the vicinity of SRS. Two notable earthquakes have occurred within 320 kilometers (200 miles) of the SRS. The first was a major earthquake in 1886 centered in the Charleston area with an estimated Richter magnitude of 6.8. The second earthquake was the Union County, South Carolina, earthquake of 1913, which had an estimated Richter magnitude of 6.0 and occurred about 160 kilometers (100 miles) from the SRS. Two earthquakes have occurred on the SRS during recent years. One on June 8, 1985, with a local magnitude of 2.6, and the other on August 5, 1988, with a local magnitude of 2.0. Appendix C of Volume 1 provides a complete description of the affected environment at the SRS in this category.

4.3.7 Air Resources

The annual average temperature at the SRS is 17.8 degrees C (64 degrees F); monthly averages range from 7.2 degrees C (45 degrees F) in January to 27.2 degrees C (81 degrees F) in July. Relative humidity readings taken four times per day range from 36 percent in April to 98 percent in August. The average annual precipitation at the SRS is approximately 122 centimeters (48 inches). Precipitation distribution is fairly even throughout the year, with the highest precipitation in the summer and the lowest in autumn. Winter storms in the SRS area occasionally bring strong and gusty surface winds with speeds as high as 32 meters per second (72 miles per hour).

The SRS is in a Class II area in attainment with National Ambient Air Quality Standards (NAAQS) for pollutants, which include sulfur dioxide, nitrogen oxides, particulate matter, lead, ozone (as volatile compounds), and carbon monoxide. The SRS has demonstrated its compliance with the South Carolina Department of Health and Environmental Control regulation R.61-62.5, Standard 8, "Toxic Air Pollutants," which regulates the emission of 257 toxic substances. Appendix C of Volume 1 provides a more detailed description of the affected environment in this category.

4.3.8 Water Resources

The Savannah River bounds the SRS on its southern border for about 32 kilometers (20 miles), approximately 260 kilometers (160 miles) from the Atlantic Ocean. At the SRS, Savannah River flow averages about 283 cubic meters (10,000 cubic feet) per second. Five principal tributaries to the Savannah River are on the SRS: Upper Three Runs Creek, Four Mile Branch Creek, Pen Branch Creek, Steel Creek, and Lower Three Runs Creek. Neither of the sites identified for the Savannah River ECF is located on the 100-year floodplain. Further discussion on the creeks in the SRS as well as the 100-year floodplain is available in Volume 1, Appendix C. Approximately 200 Carolina Bays are scattered across the SRS. Carolina Bays are naturally occurring closed depressions that often hold water. The quality of the water in the Savannah River and the SRS streams is such that on April 24, 1992, the South Carolina Department of Health and Environmental Control changed the classification of these waterways from "Class B waters" to "Freshwaters." This action imposes a more stringent set of water quality standards.

Excellent quality groundwater is abundant in this region of South Carolina from many local aquifers. The main source of recharge to the groundwater is rainfall and the direction of flow in the vadose zone is predominantly downward. In general, the vadose zone thickness ranges from approximately 40 meters (130 feet) in the northernmost part of the SRS to 0 meter where the water table intersects wetlands, streams, or creeks. The groundwater beneath 5 to 10 percent of the SRS has been contaminated by industrial solvents, metals, tritium, or other constituents used or generated on the Site. Appendix C of Volume 1 provides a complete description of the affected environment at the SRS in this category.

4.3.9 Ecological Resources

At the time of acquisition by the U.S. Government, the SRS was approximately two-thirds forested and one-third cropland and pasture. At present, more than 90 percent is forested and an extensive forest management program is conducted by the Savannah River Forest Station. The SRS is an important contributor to the biodiversity of Georgia and South Carolina. Carolina Bays, the Savannah River Swamp, and several relatively intact longleaf pine-wiregrass communities provide important contributions to the diversity of biota of the SRS and of the entire region.

The removal of all human inhabitants in 1951 and the restoration of forest cover since then have provided the wildlife associated with the wetlands of the Savannah River and the pine-dominated sand hills of coastal South Carolina found on the SRS with excellent wildlife habitat. A more thorough treatment of the topic of ecological resources at the SRS is provided in Volume 1, Appendix C. Also presented therein is a description of threatened, endangered, and candidate plant and animal species known to occur or that might occur on the SRS.

4.3.10 Noise

The major noise sources at SRS occur primarily in developed operational areas and include various facilities, equipment, and machines (e.g., cooling towers, transformers, engines, pumps, boilers, steam vents, paging systems, construction and materials-handling equipment, and vehicles). Major noise sources outside the operational areas consist primarily of vehicles and railroad operations. Existing SRS-related noise sources of importance to the public are those resulting from the transportation of people and materials to and from the Site. These sources include trucks, private vehicles, helicopters, and freight trains. In addition, a portion of the air cargo and business travel using commercial air transport through the airports at Augusta, Georgia, and Columbia, South Carolina, are attributable to SRS operations. Appendix C of Volume 1 provides a complete description of the affected environment at the SRS in this category.

4.3.11 Traffic and Transportation

The SRS is surrounded by a system of interstate highways, U.S. highways, state highways, and railroads. The regional transportation networks service the four South Carolina counties and two Georgia counties that generate about 90 percent of SRS commuter traffic.

The SRS transportation infrastructure consists of more than 230 kilometers (143 miles) of primary roads, 1,931 kilometers (1,200 miles) of unpaved secondary roads, and 103 kilometers (64 miles) of railroad track. These roads and railroads provide connections among the various SRS facilities and to off-site transportation linkages.

4.3.12 Occupational and Public Health and Safety

The sources of radiation exposure to individuals consist of natural background radiation

from
cosmic, terrestrial, and internal body sources; radiation from medical diagnostic and therapeutic practices; and radiation from man-made sources, including consumer products, industrial products, and nuclear facilities. Programs are in place at the Savannah River Site to protect workers from radiological and non-radiological hazards. These programs help to maintain the doses to workers well
below the regulatory dose limit of 5 rem/year and the DOE Administrative Control Level of
2 rem/year. Appendix C of Volume 1 provides a complete description of the affected environment at
the SRS in this category.

4.3.13 Utilities and Energy

The principal source of water for SRS facilities is the Savannah River, with the remainder supplemented by groundwater wells. The Savannah River Site has its own electric-generating facility,
although it purchases much of the power it uses from the South Carolina Electric and Gas Company.

4.3.14 Materials and Waste Management

The SRS generates high-level radioactive waste, transuranic waste, low-level radioactive waste, hazardous waste, mixed waste, and sanitary waste. DOE treats and stores waste generated from on-site operations at the SRS in waste management facilities. This includes approximately 20,000 cubic meters (700,000 cubic feet) of low-level waste generated annually. SRS packages low-level waste for disposal on the site in accordance with the waste category and its estimated surface dose rate.

Mixed low-level waste contains low-level radioactive materials and hazardous wastes. The SRS mixed waste program consists primarily of providing safe storage until treatment and disposal facilities are available. Appendix C of Volume 1 provides a complete description of the affected environment for this category.

4.4 HANFORD SITE

4.4.1 Overview

As mentioned previously, naval spent nuclear fuel has been shipped to the Expended Core Facility (ECF) at the Idaho National Engineering Laboratory (INEL) for examination since 1957. An
alternative under consideration to performing spent naval nuclear fuel inspections at the INEL-ECF is
to construct a facility providing similar capabilities at the Hanford Site. Two options for relocating
an alternate ECF at the Hanford Site are to: (1) construct a new ECF between the 200 East and 200
West Areas adjacent to the proposed spent nuclear fuel storage facility, or (2) modify the currently
unused Fuels and Materials Examination Facility (FMEF), located in the 400 Area, to perform ECF operations (see Figure 4.4-1).

This section provides a brief summary of the affected environment at Hanford. A detailed discussion of the Hanford Site affected environment is contained in Volume 1, Appendix A. The reader should refer to the applicable sections therein for additional information.

4.4.2 Land Use

The Hanford Site (which has been designated a National Environmental Research Park) encompasses approximately 1450 square kilometers (560 square miles) and includes several Department of Energy (DOE) operational areas. Most of the site is open, vacant land with only about
6 percent of the land occupied by constructed facilities. Land uses in the surrounding area include
urban and industrial development, irrigated and dry-land farming, and grazing.

The Hanford Site includes some land-use resources that Native Americans have expressed an interest in, regarding the Treaty of 1855. DOE is assisting them in this effort. Details are provided
in Volume 1, Appendix A.

Figure 4.4-1. Hanford Site map. 4.4.3 Socioeconomics

The Hanford Site plays a dominant role in the socioeconomics of the Tri-Cities (Richland, Pasco, and Kennewick) and other parts of Benton and Franklin counties. Approximately 380,000 people live within an 80-kilometer (50-mile) radius of the site. The agricultural community also represents a sizeable part of the local economy. Any major changes in Hanford activity would potentially most affect the Tri-Cities and other areas of Benton and Franklin counties. These areas in particular, but generally the 10 counties surrounding the Hanford Site, constitute the designated region of influence (Volume 1, Appendix A).

Hanford employment accounted for nearly one-quarter of the total non-agricultural jobs in Benton and Franklin counties in 1991. Approximately 93 percent of the direct employment at Hanford consists of residents of Benton and Franklin counties; approximately 81 percent reside in the Tri-Cities area. Population in the two counties increased by about 4 percent from 1980 to 1990.

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," requires federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs and activities on minority and low-income populations. An adverse environmental impact is a deleterious environmental impact determined to be unacceptable or above generally accepted norms. A disproportionately high impact refers to an impact (or risk of an impact) in a low-income or minority community that significantly exceeds that on the larger community. Data available from the U. S. Census of 1990 have been used to develop information on the locations of minority and low-income populations within approximately 50 miles of the Hanford Site, and are provided in Appendix A to this volume of the Environmental Impact Statement. These data were developed in a manner which ensures that they are consistent with the data on the total population provided in Appendix A.

4.4.4 Cultural Resources

The Hanford Site is rich in cultural resources. It contains numerous, well-preserved archaeological sites representing both the prehistoric and historical periods and is still thought of as a homeland by many Native American people. Two single sites and seven archaeological districts are included in the National Register of Historic Places. Management of Hanford's cultural resources follows the Hanford Cultural Management Plan and is conducted by the Hanford Cultural Resources Laboratory of Pacific Northwest Laboratory. DOE is assisting Native Americans who have expressed an interest in renewing their use of some Hanford land-use resources, in accordance with the Treaty of 1855. Details are provided in Volume 1, Appendix A.

4.4.5 Aesthetic and Scenic Resources

The land in the vicinity of the Hanford Site is generally flat. Rattlesnake Mountain forms the western boundary of the Site, and Gable Mountain and Gable Butte are the highest land forms within the Site. Both the Columbia River, flowing across the northern part of the Site and forming the eastern boundary, and the spring-blooming desert flowers provide a source of visual enjoyment to people. The White Bluffs, steep bluffs above the northern boundary of the river in this region, are a striking feature of the landscape.

4.4.6 Geology

The Hanford Site is located within the central part of the Pasco Basin of the Columbia Plateau. Its surface features were formed by catastrophic floods and have undergone little modification since, with the exception of more recently formed sand dunes. The elevation of the Site varies from about 105 meters (345 feet) above mean sea level in the southeast corner to about 245 meters (803 feet) in the northwest. Much of the Hanford Site is underlain by sand, gravel, and cobble deposits which could have economic value. The major geologic units and a description of them can be found in Volume 1, Appendix A.

Seismicity of the Columbia Plateau is relatively low when compared to other regions of the Pacific Northwest. There are several major volcanoes in the Cascade Range west of the Hanford Site. The nearest is Mount Adams which is about 165 kilometers (102 miles) from the Site. The most active volcano is Mount St. Helens which is about 220 kilometers (136 miles) west-southwest from Hanford.

4.4.7 Air Resources

The Hanford Site is located in a semi-arid region where the climate is mild and dry, with occasional periods of high winds. The summers are generally hot and dry; the winters are relatively cool and mild. Average monthly temperatures at the Hanford Site range from -1.5 degrees C (29.3 degrees F) in January to 24.7 degrees C (76.5 degrees F) in July. The annual average relative humidity is 54 percent and is usually highest in winter (approximately 75 percent) and lower in summer (about 35 percent). The Cascade Mountains west of the Hanford Site greatly influence the local climate by acting as a natural barrier to Pacific Ocean storm systems. This contributes to the Site's relatively low average annual precipitation of 16 centimeters (6.3 inches). This range also serves as a source of cold air drainage which has a considerable effect on the wind regime on the Hanford Site.

Air quality is within federal standards. Details of the non-radiological air quality and the radiological air quality are provided in Appendix A of Volume 1.

Information on severe weather, precipitation extremes, and air dispersion/stagnation characteristics is provided in Volume 1, Appendix A for the Hanford Site. The source of meteorological information used in analytical calculations is provided in Attachment F.

4.4.8 Water Resources

The major surface water features near the Hanford Site are the Columbia and Yakima Rivers. The Columbia River flows through the northern part of the Site at an average annual flow rate of about 3400 cubic meters per second (120,000 cubic feet per second). The Yakima River, which has a low annual flow rate compared to the Columbia River, flows along the southern portion of the Hanford Site at an average annual rate of 104 cubic meters per second (3673 cubic feet per second).
The Hanford ECF site or the modified FMEF site would not be affected by a 500-year flood of the Columbia River. Details are provided in Volume 1, Appendix A.

The State of Washington Department of Ecology classifies the Columbia River as Class A (excellent) from the Grand Coulee Dam, past the Hanford Site, to the mouth of the river at the Pacific Ocean. The Hanford Reach of the Columbia River is the last free-flowing portion of the river in the United States. Radiological monitoring shows low levels of radionuclides in the Columbia River. Hydrogen-3 (tritium), iodine-129, and uranium are found in slightly higher concentrations downstream of the Hanford Site than upstream, but are well below concentration guidelines established by the DOE and the U.S. Environmental Protection Agency (EPA) drinking water standards.

Groundwater quality on the Hanford Site has been affected by defense-related activities to produce nuclear materials. While most of the Site does not have contaminated groundwater, large underlying areas of the Site do have elevated levels of both radiological and non-radiological constituents.
The liquid effluents, discharged into the ground, have carried with them certain radionuclides and chemicals which move through the soil column at varying rates, eventually entering the groundwater forming plumes of contamination. Groundwater monitoring is conducted on an annual basis. Results indicate that concentrations of various radionuclides in some wells in or near operating areas exceeded drinking water standards. Tritium continues to slowly migrate with the groundwater flow where it enters the Columbia River. Nitrate concentrations also exceeded drinking water standards at various locations around the Hanford Site. More information on groundwater quality can be found in Volume 1, Appendix A.

4.4.9 Ecological Resources

The Hanford Site is a relatively large, undisturbed area of shrub-steppe vegetation that contains numerous plant and animal species adapted to the region's semi-arid environment. The vegetation at the Hanford Site consists of 10 major kinds of plant communities, with cheatgrass the dominant plant on fields. More than 300 species of insects, 12 species of amphibians and reptiles, and about 39 species of mammals are found on the Hanford Site. The horned-lark and western meadowlark are the most abundant nesting birds. A more thorough treatment of the topic of ecological resources at the Hanford Site is provided in Volume 1, Appendix A. Also presented therein is a description of threatened and endangered species. These include four species of plants, six species of birds, and one species each of mammals and insects.

4.4.10 Noise

Hanford measurements of the propagation of noise have been concerned primarily with occupational noise at work sites. Environmental noise levels have not been extensively evaluated because of the remoteness of most Hanford activities. Most industrial facilities on the Hanford Site are located far enough away from the site boundary that noise levels at the boundary are not measurable or are barely distinguishable from background noise levels. Some field activities, such as well drilling and sampling, have the potential for producing noise in the field apart from major permanent facilities that could be disruptive to wildlife.

4.4.11 Traffic and Transportation

The area is serviced by a system of interstate highways and state roads. Personnel and most material shipments are transported by road. Bulk materials or large items are shipped by barge. Rail transportation is used to move irradiated fuel and certain high-level radioactive solid wastes and to transport equipment and materials.

Hanford's on-site road network consists of rural arterial routes. Only 65 of the 288 miles of paved roads at Hanford are accessible to the public. On-site rail transport is provided by a short-line railroad owned and operated by the DOE. This line connects just south of the Yakima River with the Union Pacific, which in turn interchanges with the Washington Central and Burlington Northern Railroads at Kennewick. The Hanford Site infrequently uses the Port of Benton dock facilities on the Columbia River for off-loading large shipments. Overland trailers are then used to transport those shipments to the Site.

4.4.12 Occupational and Public Health and Safety

Programs are in place at the Hanford Site to protect workers from radiological and non-radiological hazards. In 1989, about 9000 individuals were monitored at the Hanford Site, of which 6000 received a measurable radiation dose equivalent to an average annual dose of 0.1 rem per person. This is well below the regulatory dose limit of 5 rem per year and the DOE administrative control level of 2 rem per year.

Doses and exposures to the public from airborne releases at the Hanford Site are calculated and reported annually. It is calculated that the maximally exposed off-site individual would receive an exposure of 0.02 millirem per year of radioactive emissions, while the average exposure to the public would be 0.002 millirem per year.

4.4.13 Utilities and Energy

The principal source of water in the Tri-Cities and at the Hanford Site is the Columbia River. Electrical power for the Hanford Site is purchased wholesale from the Bonneville Power Administration, a federal power marketing agency. Hydropower, and to a lesser extent coal and nuclear power, are used to generate the region's electricity.

4.4.14 Materials and Waste Management

The Hanford Site contains several waste areas associated with nuclear defense-related materials. These areas are scheduled for remediation in accordance with the Hanford Federal Facility Agreement and Consent Order.

The following discussion briefly describes the current waste disposal practices at the Hanford Site. For more detailed information, and information on historical waste disposal practices, refer to Volume 1, Appendix A.

Wastes at the Hanford Site are generated by both facility operations and environmental restoration activities. Non-dangerous solid waste is disposed of at the Solid Waste Landfill located in the 200 Area. The existing capacity of this landfill will be expended by the mid to late 1990s. Newly generated non-radioactive hazardous waste is shipped off-site for treatment, recycling, recovery, and/or disposal.

Low-level mixed waste contains low-level radioactive materials and hazardous wastes. These wastes are either stored until technology is modified or verified to allow treatment or are evaporated through an evaporator. Solid low-level radioactive waste is placed in unlined, shallow trenches at the 200 Area Low-Level Waste Burial Grounds. Hanford also receives low-level waste from off-site generators for disposal. High-level wastes are being stored in single-shell and double-shell tanks until a treatment facility is constructed to allow treatment and disposal of the waste.

Transuranic waste is stored in above-ground storage facilities in the Hanford Central Waste Complex and Transuranic Waste Storage and Assay Facility. This waste is planned to be shipped to the Waste Isolation Pilot Plant in New Mexico for final disposal.

4.5 OAK RIDGE RESERVATION

4.5.1 Overview

As mentioned previously, naval spent nuclear fuel has been shipped to the Expended Core Facility (ECF) at the Idaho National Engineering Laboratory (INEL) for examination since 1957. An alternative to continuing naval spent nuclear fuel operations at the ECF at INEL is to construct a facility providing similar capabilities at the Oak Ridge Reservation (ORR). The new ECF would be sited near the K-25 Site which is located on the western portion of the ORR (see Figure 4.5-1). A separate security area would be established specifically to enclose the ECF at ORR, with all access controlled by the Naval Reactors Program as has always been the case at the ECF at INEL.

This section provides a brief summary of the affected environment at the Oak Ridge Reservation. A detailed discussion of the ORR affected environment is contained in Volume 1, Appendix F. The reader should refer to the applicable sections of that appendix for additional information and for information source references.

4.5.2 Land Use

The ORR is located on approximately 54 square miles (140 square kilometers) of federal land within Anderson and Roane Counties, Tennessee, with Knox and Loudon Counties to the south. Most of the ORR is located within the corporate limits of the city of Oak Ridge. Knoxville is located approximately 30 miles (48 kilometers) southeast of Oak Ridge and is the largest city in the area. The ORR includes three intensively developed industrial areas at the Y-12 Plant, the Oak Ridge National Laboratory (ORNL), and the K-25 Site separated by mostly undeveloped forest land. Surrounding land uses include residential, commercial, public, and industrial areas in the city of Oak Ridge and rural areas characterized by residences, small farms, forest, and pastures. Approximately 21 square miles (54 square kilometers) of undeveloped ORR land have been designated as a National Environmental Research Park.

Figure 4.5-1. Oak Ridge Reservation site map.

4.5.3 Socioeconomics

Socioeconomic parameters are defined in this Environmental Impact Statement for a region of influence encompassing Anderson, Knox, Roane, and Loudon Counties, Tennessee. About 92 percent of ORR employees presently live in this region of influence. The employment level at the ORR in 1990 was 17,082 persons. The 1990 population of 489,230 in the region of influence is expected to increase at less than 1 percent annually through the year 2004, to 538,820 people. The housing stock, with a 1990 vacancy rate of 1.5 percent, is expected to grow in proportion to the population.

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," requires federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs and activities on minority and low-income populations. An adverse environmental impact is a deleterious environmental impact determined to be unacceptable or above generally accepted norms. A disproportionately high impact refers to an impact (or risk of an impact) in a low-income or minority community that significantly exceeds that on the larger community. Data available from the U. S. Census of 1990 have been used to develop information on the locations of minority and low-income populations within approximately 50 miles of the ORR, and are provided in Appendix F to this volume of the Environmental Impact Statement. These data were developed in a manner which ensures that they are consistent with the data on the total population provided in Appendix F.

4.5.4 Cultural Resources

A cultural resources survey conducted in 1975 did not identify any cultural resources on the proposed Oak Ridge ECF site. Therefore, no prehistoric or historic resources are expected to be located on the proposed Oak Ridge ECF site. There are no known Native American resources on the proposed site of the Oak Ridge ECF. Further discussion is provided in Appendix F of Volume 1.

4.5.5 Aesthetic and Scenic Resources

The view on and near the ORR consists mainly of rural land. Views are limited by hilly terrain, forest cover, and frequent haziness. The three main developed areas at the Y-12 Plant, ORNL, and K-25 Site have low vulnerability to visual impacts (visual sensitivity); undeveloped ORR lands range from low to moderate visual sensitivity.

4.5.6 Geology

The ORR lies within the western portion of the Valley and Ridge Province, near the boundary with the Cumberland Plateau. The Valley and Ridge Province is characterized by numerous linear ridges and valleys which extend northeast-southwest. Local geology is characterized by sedimentary rocks of Cambrian and Ordovician age. Areas of the ORR underlain by limestones and dolomites contain sinkholes and caves ("karst" geology). Soils generally belong to the Ultisol order, characterized as moderately acidic soils that exhibit severe mineral weathering with precipitation of iron oxides. No prime or unique farmlands are located on the ORR.

From 1811 to 1975, five earthquakes or earthquake series with Modified Mercalli Intensity (MMI) of V to VI have affected the ORR area. No MMI VII earthquakes have been recorded in the ORR during this period. An MMI VII earthquake does not typically cause severe damage, but rather causes breaking of weak chimneys at the roof line, cracks in masonry, and the falling of plaster, loose bricks, and stones. MMI VII earthquakes generally occur one order of magnitude less frequently than MMI V to VI earthquakes. Seismic records indicate that the ORR is located in a region of moderate seismic activity having an average of one to two earthquakes per year with seismic activity occurring in bursts followed by long periods of no activity. No deformation of recent surface deposits has been detected, and seismic shocks from the surrounding, more seismically active areas are dissipated by distance from the epicenter. The ORR is located in Uniform Building Code Zone 2A.

4.5.7 Air Resources

Climate at the ORR is characterized by moderate temperatures (low daily average of 36.7yF in January and high daily average of 76.6yF in July), ample precipitation (annual average of 54.0 inches), and frequent summer thunderstorms. Although infrequently subjected to tornadoes, the ORR did experience a tornado from a severe thunderstorm in February 1993. The tornado passed the Y-12 Plant and ended just north of Knoxville. Wind speeds along the tornado path ranged from 40 miles per hour (18 meters per second) to nearly 130 miles per hour (58 meters per second). As of 1991, the areas within the Air Quality Control Region which includes the ORR were designated as in attainment with respect to all National Ambient Air Quality Standards. Great Smoky Mountains National Park, a Prevention of Significant Deterioration Class I area, is located roughly 30 miles to the southeast. The estimated 50-year effective dose equivalent to any member of the public due to airborne radiological emissions from the ORR is approximately 3.3 millirem. This level is well under regulatory limits.

4.5.8 Water Resources

The ORR is drained by the Clinch River and its network of tributaries. The Clinch River, a tributary of the Tennessee River, extends roughly 350 miles and drains roughly 4,410 square miles. The section of the river bordering the ORR is impounded by Melton Hill Dam and is a navigable component of the inland waterway system. The average discharge from Melton Hill Dam between 1963 and 1979 was 150 cubic meters (5,300 cubic feet) per second. The Clinch River is the principal source of water withdrawn to meet operational demands on the ORR. The only groundwater beneath the ORR suitable for withdrawal is found in the Knox Aquifer, but withdrawals are few due to the abundance of surface water. Concentrations of radiological and non-radiological contaminants above applicable water standards have been observed at a number of groundwater monitoring wells within the ORR. Such concentrations are probably a result of past waste disposal practices (such as the discharge of radioactive material to ponds and impoundments). However, data indicate that generally the contamination remains close to the source. Further discussion concerning the water quality at ORR is provided in Appendix F of Volume 1.

4.5.9 Ecological Resources

Most undeveloped land on the ORR supports forest, including naturally established second growth forest and pine plantations that have been established on former agricultural lands. Aquatic habitats on the ORR include tailwaters, impoundments, reservoir embayments, large streams, small perennial streams, and wetlands. Wetlands on the ORR include shallow embayments on the Clinch River impoundments, narrow strips of forested wetlands along groundwater seeps and creeks, and abandoned farm ponds. Twenty-five plant and animal species known to be present on the ORR are listed by the Tennessee Department of Environment and Conservation as either endangered, threatened, or of special concern.

4.5.10 Noise

Noise from the operation of industrial facilities and equipment on the ORR is primarily limited to the developed areas at the Y-12 Plant, ORNL, and K-25 Site. Noise from other parts of the ORR is generally limited to vehicular and rail traffic. Noise at the ORR boundary is generally indistinguishable from background noise.

4.5.11 Traffic and Transportation

Segments of some arterial roads in the vicinity of the ORR operate close to design capacity at certain times. Several arterial roads that are open to the public traverse ORR lands. The Clinch River is a navigable component of the inland waterway system but primarily serves only recreational boaters. Airports in the vicinity of the ORR include the McGhee Tyson Airport in Knoxville and numerous smaller private airfields.

4.5.12 Occupational and Public Health and Safety

Health impacts to the public are minimal due to administrative and design controls at ORR facilities that keep releases of radioactive or otherwise hazardous materials to the environment in compliance with applicable regulatory standards. Occupational doses to persons working at ORR facilities also fall within regulatory limits. Refer to Appendix F of this volume for detailed information in this area.

4.5.13 Utilities and Energy

The Clinch River and Melton Hill Reservoirs provide all water resources to the ORR and the city of Oak Ridge through two pumping stations. The ORR uses an average of 69.3 million liters (18.3 million gallons) per day. Total potable water capacity available to the ORR is 152 million liters (40.2 million gallons) per day, obtained through the K-25 and Y-12 treatment plants. Electric power is provided to the ORR by the Tennessee Valley Authority. The current ORR power demand is approximately 115 megawatts, while the connected capacity of ORR facilities is approximately 920 megawatts. The average usage of natural gas at the ORR in 1994 was 3.6 billion Btu per day, compared to a contractual capacity of 7.6 billion Btu per day.

4.5.14 Materials and Waste Management

Each of the three main areas of the ORR is responsible for its own air and wastewater discharges and the associated treatment facilities. Non-radioactive hazardous wastes are also handled by each area, typically by shipment to off-site commercial treatment or disposal enterprises. Facilities for managing radioactive wastes, radioactive mixed wastes, and sanitary and industrial wastes generally involve more than one of the areas or involve land/facilities outside the area boundaries. Solid sanitary and industrial wastes are disposed of on the ORR. Most radioactive and mixed wastes are stored on-site pending future disposal actions. The Toxic Substance Control Act Incinerator, located at the K-25 Site, is used to incinerate uranium-contaminated polychlorinated biphenyl wastes and other mixed wastes.

4.6 NEVADA TEST SITE

4.6.1 Overview

As mentioned previously, naval spent nuclear fuel has been shipped to the Expended Core Facility (ECF) at the Idaho National Engineering Laboratory (INEL) for examination since 1957. Two of the alternatives under consideration result in the creation of a facility similar to ECF at the DOE-owned Nevada Test Site (NTS) in Nevada. A detailed description of the environment at the NTS is provided in Volume 1, Appendix F. This section provides a summary of some of the highlights from that volume. Therefore, specific source references for information contained in this section are omitted here but can be found in Volume 1, Appendix F.

A site has been identified as a possible location for the construction of a full-capability ECF at the Nevada Test Site. The potential location for the Nevada ECF is in Area 5 in the southeast section of the NTS, adjacent to Mercury Highway and south of the NFS High Explosive Assembly/ Disassembly Unit (see Figure 4.6-1). A separate security area would be established specifically to enclose the Nevada Test Site ECF, with all access controlled by the Naval Reactors Program as has always been the case at the Idaho ECF. This would place the Nevada ECF in close proximity to the location being proposed under one of the Centralization alternatives for construction and operation of an interim spent nuclear fuel storage facility.

4.6.2 Land Use

The NTS occupies an area of approximately 3,500 square kilometers (1,350 square miles) in southern Nevada in a remote area about 104 kilometers (65 miles) northwest of Las Vegas, Nevada. The southern two-thirds of the NTS is dominated by three large valleys or basins: Yucca, Frenchman, and Jackass flats. Mountain ridges and hills rise above gradually sloping stream-deposited soil fans, enclosing these basins. The northern and northwestern sections of the NTS are dominated by Pahute Mesa and Ranier Mesa. The NTS does not contain any public recreation facilities and only a very small percentage of the land is occupied by constructed facilities. The NTS is almost entirely surrounded by other federally owned lands which buffer it from lands open to the public. The NTS is Figure 4.6-1. Candidate site for an Expended Core Facility at the Nevada Test Site. bordered by the Nellis Air Force Range on the north, east, and west, and by the Bureau of Land Management on the south and southwest.

4.6.3 Socioeconomics

Socioeconomic parameters defined in this Environmental Impact Statement are for a two-county region of influence encompassing Clark and Nye Counties, Nevada. Ninety-eight percent of NTS employees live in Clark County (88 percent) or Nye County (10 percent). Economic conditions have continued to improve in Southern Nevada since the mid-1980s. Economic growth has been accelerated relative to the national trends because of the expansion in hotel and gaming markets. Appendix F of Volume 1 provides a complete description of the affected environment at the NTS in this category.

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," requires federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs and activities on minority and low-income populations. An adverse environmental impact is a deleterious environmental impact determined to be unacceptable or above generally accepted norms. A disproportionately high impact refers to an impact (or risk of an impact) in a low-income or minority community that significantly exceeds that on the larger community. Data available from the U. S. Census of 1990 have been used to develop information on the locations of minority and low-income populations within approximately 50 miles of the NTS, and are provided in Appendix F to this volume of the Environmental Impact Statement. These data were developed in a manner which ensures that they are consistent with the data on the total population provided in Appendix F.

4.6.4 Cultural Resources

People have inhabited the NTS site for approximately 12,000 years. The area of the NTS was inhabited by Shoshone and Southern Paiute Native American tribes prior to European settlement. These tribes are known to be affiliated with sites located in the northern portions of the NTS including the Pahute and Rainier Mesas. No prehistoric or historic resources are expected to be located on the proposed site for the ECF facilities. Also, there are no areas contained in the site that are subject to Native American Treaty rights. Appendix F of Volume 1 provides a complete description of the affected environment at the NTS in this category.

4.6.5 Aesthetic and Scenic Resources

The view across the NTS comprises a mixture of open desert, mountain ranges, and industrial features. Areas on and surrounding the NTS are generally of low to moderate vulnerability to visual impact (visual sensitivity). Appendix F of Volume 1 provides a more complete description of the affected environment at the NTS in this category.

4.6.6 Geology

The NTS lies in the southern part of the Great Basin Section of the Basin and Range Physiographic Province. Local geology is characterized by sediment-filled topographically closed valleys surrounded by ranges composed of sedimentary rocks and compacted volcanic ash and lava. Appendix F of Volume 1 provides a complete description of the affected environment at the NTS in this category.

4.6.7 Air Resources

The climate at lower elevations at the NTS is characterized by bright sunlight, limited precipitation, low relative humidity, and large daily temperature ranges. Climatological parameters change markedly at higher elevations. In Pahute Mesa at an elevation of 2,000 meters (6,560 feet) above mean sea level, the average daily maximum/minimum temperatures are 4.4yC/2.2yC (40yF/28yF) in January and 26.7yC/16.7yC (80yF/62yF) in July. At Yucca Flat, at an elevation of 1,200 meters (3,920 feet) above mean sea level, the average daily maximum/minimum temperatures are 10.6yC/-6.1yC (51yF/21yF) in January and 35.6yC/13.9y- C (96yF/57yF) in July.

The NTS is located in an attainment area for all criteria pollutants, and air quality in the region presently meets all applicable federal and Nevada regulations. For all activities on the NTS, the estimated effective dose equivalent to any member of the public from all airborne radionuclide emissions is approximately 0.01 millirem per year, which is well under regulatory limits.

4.6.8 Water Resources

Perennial surface water in the vicinity of the NTS is mostly limited to widely scattered springs, short river reaches, and playas (seasonally inundated lakes). Intermittent surface water bodies include ephemeral streams which briefly flow following heavy rainfall and playa lakes which contain standing water for brief periods following storms. Localized flash floods following rare heavy rainfalls can be destructive. Aquifers underlying the NTS are generally deep and between 660 and 1640 feet. Due to the scarcity of surface water, groundwater is the principal water source for NTS activities and surrounding communities. Appendix F of Volume 1 provides a complete description of the affected environment at the NTS in the general category of water resources, including both surface water and groundwater.

4.6.9 Ecological Resources

The NTS lies in an ecological transition area between the Mojave and Great Basin deserts. Terrestrial habitats on the NTS comprise desert scrub-shrub plant communities and a mountain, hill, and mesa community dominated by pinion pine and juniper. Aquatic habitats and wetlands on the NTS are limited to widely scattered springs, ephemeral stream channels, and playa lakes. Twenty-five federally and state listed threatened, endangered, or other special status species have been identified on or near the NTS. Of particular concern is the federally listed (threatened) desert tortoise, which is vulnerable to physical injury from construction and human activities, and the federally listed (endangered) Devils Hole pupfish, which is vulnerable to declining water levels.

4.6.10 Noise

Major noise sources at the NTS occur primarily in developed operational areas and include various facilities, equipment, and machines (e.g., cooling towers, transformers, engines, pumps, boilers, steam vents, paging systems, construction and materials-handling equipment, and vehicles), aircraft operations, and testing. No NTS environmental noise survey data are available. At the boundary, away from most facilities, noise from most sources is barely distinguishable from background noise levels.

4.6.11 Traffic and Transportation

Arterial roads in the vicinity of the NTS, including Nevada Route 375 and U.S. Route 95, generally support free flow of traffic. Airports in the vicinity of the NTS include McCarran International Airport in Las Vegas and numerous smaller private airports. Additional information in this category can be found in Volume 1, Appendix F.

4.6.12 Occupational and Public Health and Safety

Health impacts to the public are minimal due to administrative and design controls at the NTS facilities that keep releases of radioactive or other hazardous materials to the environment in compliance with applicable regulatory standards. Occupational doses to persons working at NTS facilities also fall within regulatory limits. Appendix F of Volume 1 provides a complete description of the affected environment at the NTS in this category.

4.6.13 Utilities and Energy

Water is presently supplied to NTS facilities at a rate of 6139 gallons per minute by 12 active wells that tap underlying groundwater (aquifers). Between 40 and 45 megawatts of electrical power is presently available to the NTS from the Nevada Power Company. Proposed expansion will bring capacity to approximately 200 megawatts.

4.6.14 Materials and Waste Management

Numerous surface and subsurface contamination sites from previously conducted nuclear tests and ancillary operations have been identified on the NTS. Non-radiological contamination on the NTS is minimal because there have been no industrial-type production operations on the NTS.

A "Mixed Waste Management Unit" is located just north of the Radioactive Waste Management Station and will be part of routine disposal operations in the near future. In May 1990, mixed waste disposal operations ceased due to Environmental Protection Agency issuance of the Land Disposal Restrictions of the Resource Conservation and Recovery Act for the Third Thirds Wastes. Active mixed waste disposal operations will commence upon completion of a National Environmental Policy Act documentation and issuance of a State of Nevada Part B permit.

Appendix F of Volume 1 provides additional documentation on materials and waste management practices at the Nevada Test Site.

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5. ENVIRONMENTAL CONSEQUENCES

5.1 NAVY AND PROTOTYPE SITES FOR NAVAL SPENT NUCLEAR

FUEL

5.1.1 PUGET SOUND NAVAL SHIPYARD: BREMERTON,

WASHINGTON

5.1.1.1 Overview of Environmental Impacts

The following sections discuss the major differences in potential environmental consequences associated with the choice of alternatives that include storage of naval spent nuclear fuel and inspection of high priority naval spent nuclear fuel at Puget Sound Naval Shipyard. The environmental consequences associated with storage of naval spent nuclear fuel at Puget Sound Naval Shipyard are based on the estimates of naval spent nuclear fuel that would be stored at Puget Sound Naval Shipyard through the year 2035 and current knowledge of the design features associated with spent fuel storage systems. The review of the environmental consequences associated with these alternatives has shown that the impact on the environment associated with these activities would be very small. There would be no impact to the Puget Sound Naval Shipyard regional environment associated with any alternatives that do not involve the Puget Sound Naval Shipyard.

5.1.1.2 Land Use

Construction of a storage area at Puget Sound Naval Shipyard for temporary naval spent nuclear fuel storage would require a modest change in the current land in use by the shipyard. A description of the alternate storage containers and water pools and approximate storage locations is provided in Attachment D. Attachment C provides a comparison of spent nuclear fuel storage in new water pools versus dry container storage. The shipyard area is already an industrial site; therefore, there would be no impact on land use. No additional land outside the naval complex would be required. The alternative of storing naval spent nuclear fuel in water pools would require that a water pool facility be constructed in the vicinity of the area that is designated for dry container storage or modification of the existing water pool to provide additional space. The water pool would have sufficient capacity to accommodate storage of all spent nuclear fuel expected to be stored at the shipyard.

In addition to the alternative involving storage at naval facilities of spent nuclear fuel generated in the future, the existing water pool facility would be used for the alternative where inspections of high priority naval spent nuclear fuel would be conducted at Puget Sound Naval Shipyard. A description of the Puget Sound Naval Shipyard water pool facility and the inspection operations under the alternative of inspecting high priority spent nuclear fuel at Puget Sound Naval Shipyard are also provided in Attachment D.

Native American rights and interests would not be modified by construction or operations associated with any of the alternatives considered.

5.1.1.3 Socioeconomics

The calculated number of direct construction and operating jobs that would be required for the 10-year period between 1995 and 2004 for each storage alternative at the shipyard is provided in **Table 5.1.1-1.** Since there would be no naval spent nuclear fuel storage or inspection activities at the shipyard under the 1992/1993 Planning Basis and Centralization alternatives, no additional jobs would be required at the shipyard under these alternatives.

Table 5.1.1-1. Number of construction and operating jobs created at Puget Sound Naval Shipyard for each alternative.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Railcar(1)	1	1	8	1	1	1	1	1	1	1
Immobile Containers on Pads(2)	1	1	1	1	2	6	8	8	8	8
Shipping Containers on Pads (3)	1	1	1	1	2	6	2	2	2	2
Water Pool Storage(2)	16	16	73	113	138	99	106	40	40	40
Water Pool Inspection(3)	0	0	82	123	142	60	60	60	60	60

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(1) Storage mode under the No Action and Decentralization alternatives.

(2) Storage mode under the Decentralization alternative.
(3) Inspection at Puget Sound would occur under the Decentralization B alternative.

The only discernible socioeconomic consequence of storing naval spent nuclear fuel at Puget Sound Naval Shipyard is that a relatively small number of construction workers (ranging from a few to a maximum of several hundred) would be required for construction of the storage area. The work force would consist of skilled craftsmen and unskilled laborers. This work force would be needed during the storage facility expansion and water pool modification and would be available from within the area.

The operation of the spent fuel storage area using dry storage containers would require additional workers to secure the fuel in the storage area and to support surveillance and monitoring activities. For the alternative involving storing fuel in immobile dry storage containers, about 20 workers would be required to handle the spent nuclear fuel when it is placed into the storage containers. This work force would normally only be needed when fuel is being inserted into the containers. For the alternative involving shipping containers, fewer workers would be needed to handle and secure the containers in the storage area. The operation of a water pool facility for the alternative involving storing naval spent nuclear fuel in a water pool would require approximately 40 additional workers. The operation of a water pool facility for the alternative involving inspection of spent nuclear fuel would require approximately 60 workers. The number required for any of the shipyard and prototype site storage alternatives would be small and is expected to be supplied from either within the existing shipyard work force or from the local work force. Considering that the Department of Defense employs approximately 10,200 civilians at the shipyard, the addition of workers to support the alternatives would have no discernible impact on the local socioeconomic conditions of the Puget Sound Naval Shipyard site and Bremerton area.

For the alternatives where dry storage containers would be manufactured, some additional jobs would be created in the locations where the containers are made. The process of selecting the container manufacturer is subject to federal procurement requirements and would be initiated after the Record of Decision. Consequently, the specific socioeconomic impacts from container fabrication cannot be specified. The net effect of container fabrication would be to create additional jobs and bolster the local economy of the area(s) where containers are made. It is considered unlikely that the selection of the contractor would depend on the alternative storage site selected, so the jobs associated with construction of casks provide no basis for selection of a storage site.

5.1.1.4 Cultural Resources

The action considered would not affect any site that is listed on the National Register of Historic Places (NPS 1991), any known archaeological areas, or any other cultural resources. Therefore, there would be no impacts to cultural resources associated with the alternative of storing or inspecting naval spent nuclear fuel at this location.

None of the alternatives considered would impact known archaeological or Native American sites. Procedures which comply with all applicable laws and regulations would be implemented to protect previously undetected archaeological and cultural sites.

5.1.1.5 Aesthetic and Scenic Resources

The naval spent nuclear fuel storage area would be located within the Puget Sound Naval Shipyard and would not affect the visual quality of the area since it is compatible with the landscape character of the site. Physical changes to the site resulting from the expansion of a spent nuclear fuel storage area would not alter this industrial setting. There are no particulate air emissions associated with storage of naval spent nuclear fuel and thus no visibility impacts are expected. No aesthetic or scenic resources in the vicinity of the shipyard would be affected by the construction and operation of the storage facility.

5.1.1.6 Geology

The expansion and operation of the naval spent nuclear fuel storage facility at this location is not expected to affect the geologic character or resources of the region. If an alternative were selected which required the storage area to be constructed, the ground would be excavated as necessary to prepare the surface. This would not affect the geologic characteristics of the underlying layers nor the characteristics of the aquifer or vadose zone.

5.1.1.7 Air Resources

5.1.1.7.1 Radiological Consequences.

If the alternative where naval spent fuel would be stored in dry storage containers were to be selected, no airborne radioactivity releases would be expected to occur as a result of normal storage operations. The fuel would be contained such that at least two barriers exist to prevent fission products from becoming airborne. These barriers would retain the spent nuclear fuel in an air-tight containment until it is moved to a permanent storage site and there would be no airborne radioactive material released from routine operations for this method of storage. The only radiation exposure would be direct radiation from the array of filled storage containers. The filled storage containers would be fenced off and shielded if necessary such that there would be no distinguishable effect on the current radiation readings at the site perimeter.

For the alternatives where naval spent nuclear fuel would be stored in a water pool and the alternative where fuel would be inspected in the Puget Sound Naval Shipyard water pool, airborne radioactivity would be emitted beyond current emissions. The airborne releases are expected to be less than the emissions from the Idaho National Engineering Laboratory (INEL) Expended Core Facility (ECF) because the water pool size and the number of inspections performed would be smaller at the shipyard and the shipyard would not conduct the shielded cell operations that are performed at ECF. To conservatively estimate the radiological consequences, airborne releases based on ECF releases from 1991 are used. The radiological source term used and the detailed calculations performed to determine expected normal releases are provided in Attachment F.

The radiation exposures to human beings due to estimated radionuclide releases to the atmosphere plus direct radiation from the stored spent nuclear fuel at the shipyards for both the alternative involving water pool storage and the alternative involving dry storage were calculated as described in Attachment F. Postulated releases were calculated for wet storage of spent nuclear fuel in a water pool plus inspection of naval spent nuclear fuel.

A person on the shipyard boundary at the location where the largest exposures would be received was used as the hypothetical maximally exposed off-site individual (MOI) for postulated releases of radioactive material from the stored spent fuel. The population data used to calculate population doses were taken from 1990 census data provided by the U.S. Census Bureau. Meteorology data were obtained as described in Attachment F. Estimated exposures to workers were also calculated.

The hypothetical exposures calculated are based on an exposure to the estimated average effluents and the direct radiation exposure for one year from the naval spent nuclear fuel stored at the shipyard. The calculations include the external effective exposure equivalent from the ground deposition, deposition to surface water, and air immersion pathways and the 50-year committed effective exposure equivalent from internal exposure through the ingestion and inhalation pathways. All pathways were considered for persons potentially exposed, except that the ingestion pathway was omitted for the workers because they do not grow their food on-site. Solubilities which would produce the highest calculated exposures were chosen for internal exposure factors. Values for human dietary consumption patterns were taken from "Age Dependent Values of Dietary Intake for Assessing Human Exposures to Environmental Pollutants" (Rupp 1980). The hypothetical exposures calculated can be converted into a risk of fatal cancer or a risk of non-fatal health detriments (e.g., non-fatal cancers, hereditary defects) based on recommendations of the International Commission on

Radiological Protection (ICRP 1991).

Attachment F summarizes the calculated exposures and fatal cancers to the worker, maximally exposed off-site individual (MOI), nearest public access (NPA), and the population from releases of radioactivity and direct radiation exposure in one year for each location and storage mode. Section 3.7 provides a comparison of the annual number of fatal cancers calculated for the general population for each location and alternative.

The number of fatal cancers calculated is so small that there would be essentially no fatal cancers resulting from the storage of naval spent nuclear fuel during the time it could reasonably be expected to continue to be stored. Putting this into perspective, it could be stated that one member of the population might experience a fatal cancer due to incident-free storage of naval spent nuclear fuel at the Puget Sound Naval Shipyard if operations continued for 15,400 years.

5.1.1.7.2 Non-radiological Consequences.

As noted in Attachment F, no increase in non-radioactive airborne emissions would be expected to result from spent nuclear fuel storage or examination facility operations. Storage and examination facility operations would not involve use of carcinogenic toxins, criteria pollutants, or other hazardous or toxic chemicals except that small quantities of industrial cleaning agents and paint thinner may be used for housekeeping and cleanliness control and these would be the same as those already used at the shipyard. Consequently, there would be no impact on ambient air quality as a result of implementing any of the alternatives at the shipyard.

If an alternative were to be selected that required a storage facility to be constructed or renovated, fugitive dust emissions would be expected to result from excavation operations. The quantity of dust generated would be small, consistent with typical excavation activities, and controlled within local requirements for dust control.

5.1.1.8 Water Resources

5.1.1.8.1 Radiological Consequences.

Spent nuclear fuel storage and inspection operations at the shipyard would not result in discharges of radioactivity in liquid effluents during routine operation regardless of the alternative selected for storage or inspection of spent nuclear fuel. The health effect due to fallout of nuclides released to the air onto the surface water is included in the analysis results discussed in Section 5.1.1.7. The air fallout impact is so small that there would be no distinguishable radiation levels in the water.

Puget Sound Naval Shipyard does not reside in the 100 or 500 year floodplain. Consequently, the floodplain would not be impacted by spent naval nuclear fuel storage and examination activities at the shipyard.

5.1.1.8.2 Non-radiological Consequences.

Other than chemicals used to maintain the storage area, no hazardous wastes would be generated by the storage of naval spent nuclear fuel at the shipyard. Any hazardous liquid effluents that may be generated at the storage area would be disposed of at an Environmental Protection Agency approved disposal site.

The only source for liquid discharges from the naval spent nuclear fuel storage operations to the environment consists of storm water runoff which would be consistent with the type of discharges associated with common light industrial facilities and related activities. It can be concluded that there would be no impact to the human environment due to runoff water from the naval spent nuclear fuel storage area.

The increased water usage associated with any alternative would be negligible compared to the existing shipyard demand.

5.1.1.9 Ecological Resources

Construction and operation of a spent fuel storage area would not impact any known habitats for threatened or endangered species and no major changes to the industrial environment are planned. Therefore, no major ecological impacts to the region would result from selection of any of the alternatives.

The conceptual location where naval spent nuclear fuel would be stored is illustrated in Attachment D. This location is within an existing industrial complex and is surrounded by buildings and paved areas. The industrial nature of the shipyard and the fact that the land has already been disturbed from its natural state by earlier activities mean that plant or animal species sensitive to disturbance by human activities would not be expected to be present. Therefore, there would be no ecological impacts associated with construction or operation of a spent nuclear fuel storage area at this location. The radiological controls that are in effect at the shipyard ensure that the radiation levels in the vicinity of the shipyard are maintained at or near natural background. Since these same controls would be applied to spent nuclear fuel activities, no ecological effects due to radioactive material would be expected to occur.

5.1.1.10 Noise

Puget Sound Naval Shipyard is an existing industrial-type environment characterized by noise from truck and automobile traffic; ship loading cranes and related diesel-powered equipment; and continuously operating transmission lines for steam, fuel, water, and related pumping systems for those and other liquids. No ambient noise level increases are expected to occur as a result of any of the alternatives. Therefore, no noise impacts would be expected to occur.

5.1.1.11 Traffic and Transportation

Shipments of radioactive materials in the Naval Nuclear Propulsion Program are required to be made in accordance with applicable regulations of the U. S. Department of Transportation, U.S. Department of Energy, and the U.S. Nuclear Regulatory Commission. The purpose of these regulations is to ensure that shipments of radioactive material are adequately controlled to protect the environment and the health and safety of the general public. These regulations are applicable to all radioactive material shipments and provide requirements for the container design, certification, and identification as applicable for the specific quantity, type, and form of radioactive material being shipped. Naval shipping container design requirements invoke shielding and integrity specifications and meet all regulatory requirements. They provide for testing of container designs, training and qualification of workers who construct containers, and quality control inspections during fabrication to ensure that the containers will meet their design requirements. A detailed description of the shipping containers used for naval spent nuclear fuel shipments is provided in Attachment A. A description of the impacts associated with normal and accident conditions associated with transportation of naval spent nuclear fuel is provided in Attachment A.

5.1.1.11.1 Regional Infrastructure.

The alternatives under consideration are described in Section 3. The No Action alternative or the first variation of the Decentralization alternative would store the naval spent nuclear fuel on-site. This alternative would reduce the number of rail shipments from the shipyard or prototype site compared to the past practice of transporting all naval spent nuclear fuel to INEL. The second variation of the Decentralization alternative would ship about 10 percent of the naval spent nuclear fuel to Puget Sound. This would have some transportation impact, but not as much as transporting all naval spent nuclear fuel off-site. The third Decentralization alternative ships all naval spent nuclear fuel to INEL, examines it, and returns it to the original shipyard or prototype site. This alternative involves more transportation than the previous practice of transporting naval spent nuclear fuel to INEL, since the naval spent nuclear fuel is not returned from INEL to the original site. The 1992/1993 Planning Basis alternative, the Regionalization at INEL alternative, or the Centralization at INEL alternative would involve the same transportation as has been required in the past, namely transportation to INEL and retention there. The Centralization alternative at the Hanford Site would result in more transportation impact than any of the previous alternatives, due to the distances and population distribution between Hanford and the shipyards and prototypes. The Centralization alternative at the Savannah River Site would result in the most transportation impact of naval spent nuclear fuel of any of the alternatives.

5.1.1.11.2 Site Infrastructure.

The alternatives associated with naval spent nuclear fuel storage and inspection at Puget Sound Naval Shipyard would create some small amount of additional site highway traffic because any additional employees needed to operate the water pool facility under the inspection or storage alternatives would need to travel to and from work. This impact is expected to be very small considering the total number of employees at the Puget Sound Naval Shipyard and the fact that the additional workers might be provided from the existing work force. Spent fuel storage and inspection activities would increase the internal traffic in the shipyard in the short-term; however, the total impact on shipyard traffic would not be detectable.

5.1.1.12 Occupational and Public Health and Safety

Detailed analyses of incident-free naval spent nuclear fuel transportation and storage and handling impacts on worker and public health are described in Attachment A (transportation) and Attachment F (storage and inspection). The transportation analysis results, and the storage and handling analysis are summarized separately in the following subsections.

5.1.1.12.1 Incident-free Transportation Occupational and Public Health and Safety.

The radiological and non-radiological health effects associated with the incident-free transportation of naval spent nuclear fuel and test specimens have been assessed for the general population, transportation workers, and hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancers as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. The details of the transportation analysis are provided in Attachment A.

5.1.1.12.2 Incident-free Occupational and Public Health and Safety During Naval Spent Nuclear Fuel Storage and Handling.

The public health and safety impacts of radioactivity releases and direct radiation from storage of naval spent nuclear fuel were analyzed as discussed in Section 5.1.1.7 and Attachment F. Attachment F summarizes the results of the analysis of radioactivity releases and direct radiation from stored naval spent nuclear fuel. This analysis shows that the exposure to the workers, maximally exposed off-site individual, and nearest public access from stored naval spent nuclear fuel would result in far less than one fatality per year. For perspective, it could be stated that one member of these population groups might experience a fatal cancer due to storage of naval spent nuclear fuel at Puget Sound Naval Shipyard if operations continued for 15,400 years.

Projections of the number of occupational accidents that might occur during construction and operation of naval spent nuclear fuel storage and examination facilities have been made for each alternative. These projections are presented in Attachment F. Based on the results of these projections, it is concluded that the number of occupational fatalities and injuries or illnesses for construction activities and storage and examination operations would be very small for any alternative.

No public or occupational radiological health and safety impacts would be expected to result from naval spent nuclear fuel storage area construction activities since the construction would not involve radioactive work.

Attachment F also discusses toxic chemical issues for naval spent nuclear fuel handling and storage. Attachment F concludes that there would be no additional types or volumes of chemicals required at the shipyards or prototype site for naval spent nuclear fuel storage. Therefore, there is no incident-free non-radiological impact resulting from storage of naval spent nuclear fuel at the shipyards or prototype site.

5.1.1.12.3 Incident-free Occupational and Public Health and Safety Effects on Environmental Justice Due to Naval Spent Nuclear Fuel Storage and Handling.

As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from normal operations associated with the management of naval spent nuclear fuel at the Puget Sound Naval Shipyard would be small under any of the alternatives considered. For example, it is unlikely that a single fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to normal operations or accident conditions for any of the alternatives considered present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is true for normal operations because the effects of routine operations are so small. It is also true for accident conditions because the consequences of any accident would depend on the random conditions at the time it occurred, and the wind directions at the Puget Sound Naval Shipyard do not display any strongly dominant direction. Similarly, the conclusion is not affected by concerns related to subsistence consumption of fish or game since environmental monitoring in the vicinity of this relatively small and restricted site has shown no detectable difference in the amounts of radioactivity present in the environment from levels in similar parts of the region.

To place the impacts on environmental justice in perspective, the risk associated with routine naval spent nuclear fuel management operations under any of the alternatives considered would be less than one fatality per year for the entire population. For comparison, in 1990 there were approximately 510,000 cancer deaths in the United States population and there were about 64,000 cancer deaths among people of color in the U. S. Even if all of the impacts associated with one of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would be unlikely to experience a single additional cancer fatality in any year. Therefore, the cancer risk for that population from naval spent nuclear fuel management would not constitute a disproportionately high and adverse impact on human health or the environment. The same conclusion can be drawn for low-income groups.

5.1.1.13 Utilities and Energy

If an alternative associated with storage of spent nuclear fuel at Puget Sound Naval Shipyard were to be selected, construction and operation of the storage area would not be expected to require a large expenditure of utilities and energy resources. Construction activities would require quantities of water and electricity typical of any small to medium size construction project. Operation of a dry container spent fuel storage facility would likely require only minimal electricity for security lighting and to support industrial equipment necessary to move spent fuel.

Alternatives associated with water pool storage and inspection would require heating, ventilation, water, and electrical systems suitable for a work environment and to properly filter and exhaust the airborne discharges to the atmosphere. The utility and energy demands and impact would be less than that identified in Section 5.2.13 for operation of ECF (10,000 MWh per year) since the water pool facility at Puget is smaller and the scope of operations would be less.

The amount of utilities and energy expected to be consumed would be a small incremental increase in the total amount of utilities and energy used at the shipyard and would not result in any discernible environmental consequence.

5.1.1.14 Facility and Transportation Accidents

5.1.1.14.1 Facility Accidents. There has never been an accident in the history of the Naval

Nuclear Propulsion Program that resulted in a significant release of radioactivity to the environment or that resulted in radiation exposure to workers in excess of abnormal occurrence limits on exposures as defined by the U.S. Nuclear Regulatory Commission. A description of potential accidents considered and a summary of the accident analyses that were conducted with regard to the inspection and storage of naval spent nuclear fuel are contained in Attachment F.

5.1.1.14.1.1 Radiological Accidents. Section 3.7.3 provides a summary of the impacts

due to the most severe accidents considered for each site. The facility accident with the greatest potential impact at Puget Sound Naval Shipyard involves accidental drainage of the water pool. An accident of this magnitude would result in less than one fatal cancer to the general population over 50 years, as described in Attachment F. The likelihood of such an accident occurring is 1 x 10-5, which is very small. For perspective, an accident such as this would not be expected to occur unless the facility operated for about 100,000 years.

5.1.1.14.1.2 Non-radiological Accidents. As discussed in detail in Attachment F, the

limiting hypothetical non-radiological accident for naval spent nuclear fuel storage in a water pool at a shipyard or prototype location would be a diesel fuel spill and fire. A catastrophic failure of a diesel fuel storage tank that might be used for an emergency diesel generator to provide backup electrical power was postulated to occur, resulting in the spilling of the entire quantity of diesel fuel with a subsequent fire. The fire would generate the following toxic chemicals:

- Carbon monoxide
- Oxides of nitrogen (90% nitric oxide and 10% nitrogen dioxide)
- Lead
- Sulfur dioxide.

Measures would be taken to reduce the health impacts of potential releases of toxic materials. These measures would involve controls to protect both workers and the general public. The naval shipyard and prototype sites have emergency planning, emergency preparedness, and emergency response programs in place to protect both workers and the public, and involve established resources such as warning communications, fire departments, and emergency command centers.

The airborne concentrations of the combustion products listed above, resulting from the fire, were calculated at the locations of the on-site individuals, an individual at the site boundary, and the general population within a 50-mile radius of the facility. Detailed results are presented in Attachment F. If the accidental fire that has been hypothesized were to actually occur, the safety measures that would be in place would ensure no adverse health impacts to the general public and minimal health impacts to the workers.

5.1.1.14.2 Transportation Accidents.

Shipments of radioactive materials associated with naval spent nuclear fuel have never resulted in any measurable release of radioactivity to the environment (NNPP 1994a). There have never been any significant accidents involving release of radioactive material during shipment since the Naval Nuclear Propulsion Program began. The effects of potential transportation accidents during the various stages of transportation of naval spent nuclear fuel are presented in Attachment A.

The health effects associated with accidents during shipments of naval spent nuclear fuel and test specimens have been assessed for the general population and the hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancers as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. Details of the transportation analysis are provided in Attachment A.

5.1.1.14.3 Other Impacts of Accidents.

In addition to the possible human health effects associated with facility or transportation accidents described in the preceding sections, other effects such as the impacts on socioeconomics and land use in the area and the costs of cleanup have been estimated in order to develop a perspective and to evaluate potential differences among alternatives.

The analyses described in Attachment F showed that an area ranging from about 8 acres extending approximately a quarter mile (for an inadvertent criticality accident) to about 110 acres extending approximately 0.9 mile (for a large airplane crashing into a dry storage container) might be contaminated to the point where exposure could exceed 100 millirem per year. Beyond these distances, the exposure would be less than 100 millirem per year, the Nuclear Regulatory Commission's standard for protection of the general population from radiation. Persons who live in this area might be evacuated or otherwise experience restrictions in their daily activities for a brief period, and those who work at locations within this area might be prevented from going to their jobs until measures had been taken to reduce the potential for exposure. It should be noted that all of the affected area within approximately a half mile from the spent nuclear fuel facility would be inside the boundaries of the federally owned site.

An accident might result in short-term restrictions on access to a relatively small area, but there would be no enduring impacts on cultural or similar resources or concerns such as Native American rights or interests, partially because the area involved would be small and partly because all remedial actions would be conducted in a careful, controlled manner in full compliance with applicable laws and regulations. The area impacted would only vary slightly among the alternatives. Overall, the risks are small so these considerations do not assist in distinguishing among alternatives.

Facility or transportation accidents associated with any of the alternatives would not have an appreciable effect on the ecology of the area, considering the potential for human health effects and the amount of land which might be affected, as described in earlier parts of this section. There is little consensus among scientists on methods for estimating the effects of radiation on ecological resources such as plant or animal life, but since human health effects for all the accidents analyzed are small and most plants and animals are not thought to be more sensitive to radiation than human beings, the small impacts on human health provide an indication that the impacts on plant and animal species in the area would also be small for all alternatives considered. Similarly, since the areas which might be contaminated to measurable levels by chemicals or radioactive material during the hypothetical accidents would be relatively small, any effects on the ecology would be limited to small areas. There are no endangered or threatened species unique to the area surrounding the federally owned site, so an accident would not be expected to result in destruction of any species for any of the alternatives considered. The effects of accidents related to any of the alternatives and any associated cleanup which might be performed would be localized in a small area which extends only a short distance beyond the boundaries of the federally owned site and thus would not be expected to appreciably affect the potential for survival of any species in the area. Based on these considerations, evaluation of impacts of accidents on ecological resources does not help to distinguish among alternatives.

5.1.1.14.4 Effects of Accidents on Environmental Justice Due to Naval Spent Nuclear

Fuel Storage and Handling.

As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from facility or transportation accidents associated with the management of naval spent nuclear fuel at the Puget Sound Naval Shipyard would be small under any of the alternatives considered. For example, it is unlikely that a single additional fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to an accident for any of the alternatives considered would present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects from accidents associated with the management of naval spent nuclear fuel would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is because the consequences of any accident would depend on the random conditions in effect at the time an accident occurred, and the wind directions at the Puget Sound Naval Shipyard are highly variable with no strongly dominant direction.

To place the impacts on environmental justice in perspective, the risk associated with accidents caused by naval spent nuclear fuel management under any of the alternatives considered would amount to less than one additional fatality per year for the entire population. For comparison, in 1990 there were approximately 40,000 traffic fatalities in the United States population and there were about 7,400 deaths caused by traffic accidents among people of color in the U. S. Even if all of the additional cancer deaths associated with an accident involving any of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would experience less than one additional fatal cancer per year. The same conclusion can be drawn for low-income groups.

5.1.1.15 Waste Management

The alternative in which naval spent nuclear fuel is stored at Puget Sound Naval Shipyard would produce limited amounts of solid municipal waste, solid low-level radioactive wastes, and hazardous wastes.
In addition, no transuranic or high-level radioactive wastes would be generated by spent nuclear fuel activities at the site under any alternative. The quantity of industrial wastes generated would be small and most likely consist of industrial cleaning agents of the type normally encountered at the site. Small quantities of sanitary wastes would result from the additional work force but this volume would be small. The wastes produced from the storage of naval spent nuclear fuel would be controlled and minimized in accordance with the existing waste management programs at the shipyard. The amount of additional wastes generated would be minimal compared to the existing baseline and would not cause any adverse impacts to public health and safety and the environment in the vicinity of the shipyard.

5.1.1.16 Cumulative Impacts

5.1.1.16.1 Radiological Cumulative Impacts. Spent nuclear fuel storage and examination at

Puget Sound would not result in discharges of radioactivity in liquid effluents during routine operations regardless of the alternative selected. Therefore, there would be no incremental addition of radioactivity to surface or ground water as a result of normal operations for any alternative. For alternatives involving the storage of spent nuclear fuel in dry storage and shipping containers, no airborne radioactivity emissions are expected, so there would be no cumulative air quality impacts associated with these storage methods. Consequently, the only radiological cumulative impacts that would result from dry storage alternatives would be due to direct radiation exposure from the stored containers of spent nuclear fuel.

For alternatives involving the storage and examination at Puget Sound of naval spent nuclear fuel in water pools, there would be no discernible direct radiation exposure to the public from the fuel elements due to the shielding provided by the water in the pool. Therefore, any cumulative impacts which would result from water pool storage (and examination at Puget Sound) would be primarily due to airborne emissions, and the addition of these emissions would cause an indiscernible change in the emissions in the area (see Section 5.1.1.7). Current operations at the site are in compliance with Title 40, Code of Federal Regulations, Part 61, "National Emission Standards for Hazardous Air Pollutants." Cumulative air emissions would not threaten to exceed any applicable air quality requirement or regulation, either federal, state, or local in radiological and non-radiological categories.

A summary of the cumulative radiological impacts is provided in the following section.

An overview of the historical radiological impacts from naval nuclear operations at the Puget Sound Naval Shipyard and from transportation of naval spent nuclear fuel is provided in Section 4.1.1.12 and detailed analyses are provided in Attachments F and A. Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

The radiological impacts associated with the alternatives where naval spent nuclear fuel would be inspected or stored at Puget Sound Naval Shipyard are very small and are described in Section 5.1.1.12, with the detailed results of analyses provided in Attachment F. In order to calculate cumulative impacts for the period between 1995 and 2035, the annual radiological impacts associated with each location and alternative were summed over 40 years. The results of this summation are tabulated in Tables 3-5 and 3-6 of Section 3.

The cumulative transportation impacts for the population groups from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated and are very small. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A and summarized in Section 3.7.4.

The total exposure to the population in the vicinity of the Puget Sound Naval Shipyard from all of the alternatives considered would be approximately 5.30 person-rem. This means that there would be much less than one fatal cancer from these operations over the entire 40-year period evaluated. The total exposure to a theoretical maximally exposed off-site individual living at the shipyard boundary for the entire 40-year period would be 7.0 x 10-3 rem due to the alternative resulting in the largest exposure. This maximally exposed off-site individual would have a 3.5 x 10-6 risk of contracting a fatal cancer during his or her lifetime due to storage of spent nuclear fuel. When existing site radiological impacts due to naval nuclear operations are added to the impacts of the most limiting spent nuclear fuel alternative, the exposure to the population would be 6.1 person-rem and to the maximally exposed off-site individual would be 7.6 x 10-3 rem. This still results in much less than one fatal cancer in the population and the risk of the maximally exposed off-site individual contracting a fatal cancer during his or her lifetime is 3.8 x 10-6.

The total exposure related to naval spent nuclear fuel activities to a worker assumed to be working continually 100 meters from the spent nuclear fuel under the alternative resulting in the largest exposure is 0.22 rem accumulated over 40 years. That corresponds to a fatal cancer risk of 8.8 x 10-5 during the worker's lifetime. The exposure to the same worker when existing site radiological impacts due to naval nuclear operations are added to the spent nuclear fuel exposure is 0.222 rem over 40 years which corresponds to a fatal cancer risk of 8.9 x 10-5 during the worker's lifetime. The impacts associated with transportation of naval spent nuclear fuel for all of the alternatives considered would be similarly low.

No contribution to cumulative impacts from accidents involving naval spent nuclear fuel has been included in the analyses presented in this Environmental Impact Statement because there has never been a nuclear reactor accident, criticality accident, transportation accident, or any release of radioactivity which had a significant effect on the environment.

Sections 4.1.1.14 and 5.1.1.15 describe the management of low-level radioactive waste and mixed waste at the site. The volume of low-level radioactive wastes which would be generated under the alternatives has not been calculated. However, considering the nature of radiological work that would be associated with spent nuclear fuel storage (and examination) activities, the amount of low-level radioactive waste produced during spent nuclear fuel activities would be much less than 20 percent of the current site generation rate (651 m3 per year). This additional radioactive waste would not introduce any changes to the site's waste management practices. The small amount of additional material involved would not impose any discernible additional stress on the capacity of the radioactive waste burial ground. Therefore, any cumulative impacts associated with the generation and disposal of additional low-level wastes would be very small.

Since no mixed, transuranic, or high-level radioactive wastes would be generated by spent nuclear fuel activities at this site under any alternative, there would be no cumulative impacts associated with these materials.

5.1.1.16.2 Non-radiological Cumulative Impacts.

An overview of the historical non-radiological impacts from naval nuclear operations at the Puget Sound Naval Shipyard and from transportation of naval spent nuclear fuel is provided in Section 4.1.1.12 and detailed analyses are provided in Attachments F and A. Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no non-radiological cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

The non-radiological impacts associated with the alternative where naval spent nuclear fuel would be inspected or stored at Puget Sound Naval Shipyard are described in Section 5.1.1.12, with the detailed results of analyses provided in Attachment F. As summarized in Section 5.1.1.12, there would be no additional chemicals required at the shipyard for naval spent nuclear fuel storage and therefore no non-radiological impacts from normal operations. Consequently, no cumulative impacts to air quality or water resources would result since the incremental addition of chemicals at the shipyard that might result from naval spent fuel activities would be very small. There are no current environmental problems associated with these materials.

The non-radiological cumulative transportation impacts for the population from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A. The non-radiological impacts associated with the transportation and storage of naval spent nuclear fuel for all of the alternatives considered would be low.

No cumulative land use impacts would be expected to occur as a result of spent nuclear fuel storage and examination at Puget Sound. The land that would be dedicated for this purpose is on existing federal property and situated in an industrial setting which has already been disturbed from its natural state (approximately 327 acres are developed land). The conversion of this space for storage of spent nuclear fuel would not result in the need to disturb undeveloped land or for additional land to be added to the federally owned property in the foreseeable future.

From a socioeconomic perspective, the introduction of naval spent nuclear fuel activities at the site would create a small number of additional jobs and could have a very small cumulative socioeconomic impact. The site currently employs approximately 10,200 civilian personnel. No shipyard employment has been associated with spent nuclear fuel activities in the past since spent nuclear fuel activities have not been conducted at the site. An average of approximately 1 to 100 additional jobs might be added as a result of possible spent nuclear fuel activities in the future. The peak number of additional jobs created at the site in any given year would be approximately 280, which is associated with construction and operation of a water pool facility for storage of spent nuclear fuel and modification of the existing water pool for limited examination of fuel. Considering that the regional labor force consists of approximately 527,000 workers, the additional number of added jobs under any alternative would have little or no discernible socioeconomic impact. These jobs would be filled either from within the existing site work force or from the available regional labor force without discernible effect. There are no foreseeable future projects planned at the site and no known projects planned in the region that would cause the small number of workers involved in naval spent nuclear fuel activities to become an important impact.

The cumulative impacts associated with non-radiological waste management are likewise expected to be small. As stated previously, any industrial wastes generated from naval spent nuclear fuel storage and examination at Puget Sound would be small and limited to industrial cleaning agents of the type normally encountered at the site. The volume of municipal solid wastes and sanitary wastes which would be generated is expected to be proportional to the number of additional workers added, and this small incremental increase would not be discernible. The amount of additional non-radiological wastes generated would not introduce any changes to the site's waste management practices and would not impose any additional stress on the capacity of on-site or off-site waste disposal or treatment facilities. Therefore, any cumulative impacts associated with the generation and disposal of additional wastes would be very small. There are no current environmental problems associated with these types of waste.

5.1.1.17 Unavoidable Adverse Effects

There are no discernible unavoidable adverse effects associated with the implementation of any of the alternatives and none which would help to choose among the alternatives.

The alternative in which naval spent nuclear fuel is inspected or stored at the Puget Sound Naval Shipyard would cause the public to be exposed to small amounts of radiation, described in Section 5.1.1.12, and would result in less than one health effect in the entire population surrounding the shipyard. Similarly, continued operation of the storage facility would produce limited amounts of solid municipal waste and solid low-level radioactive waste. These amounts of waste would not produce any major impacts in the vicinity of the Puget Sound Naval Shipyard. There will be no changes to the ecological, cultural, geological, and aesthetic resources due to the implementation of any of the alternatives. There will also be no impact on ambient noise levels.

5.1.1.18 Irreversible and Irretrievable Commitments of Resources

The only irreversible and irretrievable commitment of resources that results from the alternative in which naval spent nuclear fuel would be stored at the shipyard would be the money which would be spent by the federal government to construct the necessary facilities. The total cost of storing spent naval nuclear fuel at the shipyards and prototype ranges from approximately $1.5 billion to $5.7 billion. This cost represents the total cumulative cost over the 40-year period for all of the shipyards and prototype. This cost includes construction costs of the new storage facilities, and, depending on the alternative selected, the operation of a limited examination facility at Puget Sound Naval Shipyard combined with the costs associated with shutting down ECF, or the operational costs of the INEL-ECF. The major expense in the highest cost alternatives is the procurement of shipping containers. Refer to Section 3.7 for a comparison of the total cumulative costs among alternatives.

5.1.2 NORFOLK NAVAL SHIPYARD: PORTSMOUTH, VIRGINIA

5.1.2.1 Overview of Environmental Impacts

The following sections discuss the major differences in potential environmental consequences associated with the choice of alternatives that include storage of naval spent nuclear fuel at Norfolk Naval Shipyard. The environmental consequences associated with storage of naval spent nuclear fuel at Norfolk Naval Shipyard are based on the estimates of naval spent nuclear fuel that would be stored at Norfolk Naval Shipyard through the year 2035 and current knowledge of the design features associated with spent fuel storage containers. The review of the environmental consequences associated with these alternatives has shown that the impact on the environment at Norfolk Naval Shipyard associated with all activities is very small. There would be no impact to the Norfolk Naval Shipyard regional environment associated with any alternatives that do not involve the Norfolk Naval Shipyard.

5.1.2.2 Land Use

Norfolk Naval Shipyard has identified a centrally located area within the controlled industrial area as a potential site for spent nuclear fuel storage. The site is located approximately 1500 feet from the southern branch of the Elizabeth River. Public access to the 900 feet of river nearest the site evaluated is restricted. There are no known existing adverse environmental conditions at this site. The area is already an industrial site; therefore, there would be no impact on land use. The area identified should be sufficient depending on the type of storage mode ultimately chosen. A description of storage containers and water pools and their approximate storage locations is provided in Attachment D. Attachment C provides a comparison of spent nuclear fuel storage in new water pools versus dry container storage.

The alternative of storing naval spent nuclear fuel in water pools would require that a water pool facility be constructed in the vicinity of the area that is designated for dry container storage. The water pool would have sufficient capacity to accommodate storage of all spent nuclear fuel expected to be stored at the shipyard.

No additional land use outside the shipyard would be required.

Native American rights and interests would not be modified by construction or operations associated with any of the alternatives considered.

5.1.2.3 Socioeconomics

The calculated number of direct construction and operating jobs that would be required for the 10-year period between 1995 and 2004 for each storage alternative at the shipyard is provided in **Table 5.1.2-1.** Since there would be no naval spent nuclear fuel storage or inspection activities at the shipyard under the 1992/1993 Planning Basis and Centralization alternatives, no additional jobs would be required at the shipyard under these alternatives.

Table 5.1.2-1. Number of construction and operating jobs created at Norfolk Naval Shipyard for each alternative.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Railcar(1)	1	1	8	1	1	1	1	1	1	1
Immobile Containers on Pads(2)	1	1	1	1	2	6	8	8	8	8
Shipping Containers on Pads (2)	1	1	1	1	2	6	2	2	2	2
Water Pools(2)	16	16	70	107	132	94	103	40	40	40

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(1) Storage mode under the No Action and Decentralization alternatives.
(2) Storage mode under the Decentralization alternative.

The only discernible socioeconomic consequence of storing naval spent nuclear fuel at Norfolk Naval Shipyard is that a relatively small number of construction workers (ranging from a few to a maximum of several hundred would be required for construction of the storage area). The work force would consist of skilled craftsmen and unskilled laborers. This work force would be needed during the storage facility construction and would be available from within the area.

The operation of the spent fuel storage area using dry storage containers would require additional workers to support surveillance and monitoring activities. For the alternative involving storing fuel in immobile dry storage containers, about 20 workers would be required to handle the spent nuclear fuel when it is placed into the storage containers. This work force would normally only be needed when fuel is being inserted into the containers. For the alternative involving shipping containers, fewer workers would be needed to handle and secure the containers in the storage area. The operation of a water pool facility for the alternative involving storing naval spent nuclear fuel in a water pool would require approximately 40 additional workers. The number required for any of the shipyard and prototype site storage alternatives would be small and is expected to be supplied from either within the existing shipyard work force or from the local work force. Considering that the Department of Defense employs approximately 8,500 civilians at the shipyard, the addition of workers to support the alternatives would have no discernible impact on the local socioeconomic conditions of the Norfolk Naval Shipyard site.

For the alternatives where dry storage containers would be manufactured, some additional jobs would be created in the locations where the containers are made. The process of selecting the container manufacturer is subject to federal procurement requirements and would be initiated after the Record of Decision. Consequently, the specific socioeconomic impacts from container fabrication cannot be specified. The net effect of container fabrication would be to create additional jobs and bolster the local economy of the area(s) where containers are made. It is considered unlikely that the selection of the contractor would depend on the alternative storage site selected, so the jobs

associated
with construction of casks provide no basis for selection of a storage site.

5.1.2.4 Cultural Resources

The action considered would not affect any site that is listed on the National Register of Historic Places (NPS 1991), any known archaeological areas, or any other cultural resources. Therefore, there would be no impacts to cultural resources associated with the alternative of storing
naval spent nuclear fuel at this location.

None of the alternatives considered would impact known archaeological or Native American sites. Procedures which comply with all applicable laws and regulations would be implemented to protect previously undetected archaeological and cultural sites.

5.1.2.5 Aesthetic and Scenic Resources

The naval spent nuclear fuel storage area would be located within the Norfolk Naval Shipyard
which is an existing industrial setting and would not affect the visual quality of the area since it is
compatible with the landscape character of the site. Physical changes to the site resulting from the
construction of a spent nuclear fuel storage area would not alter this setting. There are no particulate
air emissions associated with storage of naval spent nuclear fuel and thus no visibility impacts are
expected. No aesthetic or scenic resources in the vicinity of the shipyard would be affected by the
construction and operation of the storage facility.

5.1.2.6 Geology

The construction and operation of the naval spent nuclear fuel storage facility at the Norfolk
Naval Shipyard is not expected to affect the geologic character or resources of the region. If an
alternative were selected which required a storage facility to be constructed, the ground would only be
excavated as necessary to prepare the surface. This would not affect the geological characteristics of the underlying layers nor the characteristics of the aquifer or vadose zone. For the alternative of
storing fuel in a water pool facility, the ground surface would need to be excavated to a depth of
approximately 40 feet. This excavation would not affect the geological characteristics of the area.
Since the Columbia aquifer is at a depth of 3 to 5 feet throughout the shipyard, the hydraulic considerations make a water pool facility more difficult and expensive than an above-ground storage
facility. However, if water pools were selected, all precautions necessary to protect the aquifer would
be taken.

5.1.2.7 Air Resources

5.1.2.7.1 Radiological Consequences.

If the alternative where naval spent fuel would be stored
in dry storage containers were to be selected, no airborne radioactivity releases would be expected to
occur as a result of normal storage operations. The fuel would be contained such that at least two
barriers exist to prevent fission products from becoming airborne. These barriers would retain the
spent nuclear fuel in an air-tight containment until it is moved to a permanent storage site and there

would be no airborne radioactive material released from routine operations for this method of storage. The only radiation exposure would be direct radiation from the array of filled storage containers. The filled storage containers would be fenced off and shielded if necessary such that there would be no distinguishable effect on the current radiation readings at the site perimeter.

For the alternative where naval spent nuclear fuel would be stored in a water pool, airborne radioactivity would be emitted beyond current emissions. The airborne releases for this alternative are expected to be less than the emissions from the Idaho National Engineering Laboratory (INEL) Expended Core Facility (ECF) because the water pool size and the number of inspections performed would be smaller at the shipyard and the shipyard would not conduct the shielded cell operations that are performed at ECF. To conservatively estimate the radiological consequences, airborne releases based on ECF releases from 1991 are used. The radiological source term used and the detailed calculations performed to determine expected normal releases are provided in Attachment F.

The radiation exposures to human beings due to estimated radionuclide releases to the atmosphere plus direct radiation from the stored spent nuclear fuel at the shipyards for both the alternative involving water pool storage and the alternative involving dry storage were calculated as described in Attachment F. Postulated releases were calculated for wet storage of spent nuclear fuel in a water pool plus inspection of naval spent nuclear fuel.

A person on the shipyard boundary at the location where the largest exposures would be received was used as the hypothetical maximally exposed off-site individual (MOI) for postulated releases of radioactive material from the stored spent fuel. The population data used to calculate population exposures were taken from 1990 census data provided by the U.S. Census Bureau. Meteorology data were obtained as described in Attachment F. Estimated exposures to workers were also calculated.

The hypothetical exposures calculated are based on an exposure to the estimated average effluents and the direct radiation exposure for one year from the naval spent nuclear fuel stored at the shipyard. The calculations include the external effective exposure equivalent from the ground deposition, deposition to surface water, and air immersion pathways and the 50-year committed effective exposure equivalent from internal exposure through the ingestion and inhalation pathways. All pathways were considered for persons potentially exposed, except that the ingestion pathway was omitted for the workers because they do not grow their food on-site. Solubilities which would produce the highest calculated exposures were chosen for internal exposure factors. Values for human dietary consumption patterns were taken from "Age Dependent Values of Dietary Intake for Assessing Human Exposures to Environmental Pollutants" (Rupp 1980). The hypothetical exposures calculated can be converted into a risk of fatal cancer or a risk of non-fatal health detriments (e.g., non-fatal cancers, hereditary defects) based on recommendations of the International Commission on Radiological Protection (ICRP 1991).

Attachment F summarizes the calculated exposures and fatal cancers to the worker, maximally exposed off-site individual (MOI), nearest public access (NPA), and the population from airborne releases of radioactivity and direct radiation exposure in one year for each location and storage mode. Section 3.7 provides a comparison of the annual number of fatal cancers calculated for the general population for each location and alternative.

The number of fatal cancers calculated is so small that there would be essentially no fatal cancers resulting from the storage of naval spent nuclear fuel during the time it could reasonably be expected to continue to be stored. Putting this into perspective, it could be stated that one member of the population might experience a fatal cancer due to incident-free storage of naval spent nuclear fuel at the Norfolk Naval Shipyard if operations continued for 7,100 years.

If a water pool facility would be constructed at the Norfolk Naval Shipyard and used for storage of spent nuclear fuel, the airborne emissions from the facility would be less than that identified for the Puget Sound Naval Shipyard because no spent nuclear fuel inspection operations beyond visual examinations would be conducted in the water pools.

5.1.2.7.2 Non-radiological Consequences.

As noted in Attachment F, no increase in non-radioactive airborne emissions would be expected to result from spent nuclear fuel storage facility operations. Storage facility operations would not involve use of carcinogenic toxins, criteria pollutants, or other hazardous or toxic chemicals except for small quantities of industrial cleaning agents and paint thinner that may be used for housekeeping and cleanliness control and these would be the same as those already used at the shipyard. Consequently, there would be no impact on ambient air quality as a result of implementing any of the alternatives at the shipyard.

If an alternative were to be selected that required a storage facility to be constructed or renovated, fugitive dust emissions would be expected to result from excavation operations. The quantity of dust generated would be small, consistent with typical excavation activities, and controlled within local requirements for dust control.

5.1.2.8 Water Resources

5.1.2.8.1 Radiological Consequences.

Spent nuclear fuel storage operations at the shipyard would not result in discharges of radioactivity in liquid effluents during routine operation regardless of the particular alternative chosen for storage of spent nuclear fuel. The health effect due to fallout of nuclides released to the air onto the surface water is included in the analysis results discussed in Section 5.1.2.7. The air fallout impact is so small that there would be no distinguishable radiation levels in the water.

Most of the Norfolk Naval Shipyard, including the location considered for the interim storage of naval spent nuclear fuel, is in the 100-year floodplain. However, the location considered for naval spent nuclear fuel is not in a high-hazard area (as defined by Title 10, Part 1022 of The Code of Federal Regulations for floodplains) which is an area where frequent flooding occurs. Since the majority of the shipyard is already developed and covered with impervious material, construction and operation of a naval spent nuclear fuel storage facility at the shipyard would produce no discernible impacts on the floodplain.

Flooding in the area where shipping and immobile dry storage containers are stored would not result in any adverse environmental consequences. These containers are completely sealed such that no radioactivity would be released from the interior even if they were completely submerged. In addition, the massive nature of these containers prevents them from floating or moving during a flood.

Since the shipyard resides in a floodplain, the design of the facility and equipment would minimize the potential for flooding and damage to the facility. However, in the event a water pool facility would be flooded, the exchange of pool water with the flood waters could occur. As discussed in Attachment F, Section F.1.4.2.1.6.2, the radioactivity concentration in the ECF water pool is below the Nuclear Regulatory Commission limits specified in Title 10, Part 20 of The Code of Federal Regulations for liquid effluent except for Co-60 which is slightly higher (water pools used for storage or examination of naval spent nuclear fuel would be maintained to comparable concentrations). Any release of radioactivity would have to result from the exchange of floodwater with the pool water. This exchange would reduce the level of radioactivity even further. Consequently, no adverse environmental impacts would result from flooding of water pools at naval spent nuclear fuel storage sites.

5.1.2.8.2 Non-radiological Consequences.

Other than chemicals used to maintain the storage area, no hazardous wastes would be generated by the storage of naval spent nuclear fuel at Norfolk Naval Shipyard. Any hazardous liquid effluents that may be generated at the storage area would be disposed of at an Environmental Protection Agency approved disposal site.

The only source for liquid discharges from the naval spent nuclear fuel storage operations to the environment consists of storm water runoff which would be consistent with the type of discharges associated with common light industrial facilities and related activities. It can be concluded that there would be no impact to the human environment due to runoff water from the naval spent nuclear fuel storage area.

The increased water usage under any of the alternatives would be negligible compared to the existing shipyard demand.

5.1.2.9 Ecological Resources

There are no threatened or endangered species known to exist within the shipyard and no major changes to the industrial environment are planned. Therefore, no major ecological impacts to the region would result from selection of any of the alternatives.

The conceptual location where naval spent nuclear fuel would be stored is illustrated in Attachment D. This location is within an existing industrial complex and is surrounded by buildings and paved areas. The industrial nature of the shipyard and the fact that the land has already been disturbed from its natural state by earlier activities mean that plant or animal species sensitive to disturbance by human activities would not be expected to be present. Therefore, there would be no ecological impacts associated with construction or operation of a spent nuclear fuel storage area at this location. The radiological controls that are in effect at the shipyard ensure that the radiation levels in the vicinity of the shipyard are maintained at or near natural background. Since these same controls would be applied to spent nuclear fuel activities, no ecological effects due to radioactive material would be expected to occur.

5.1.2.10 Noise

Norfolk Naval Shipyard is an existing industrial-type environment characterized by noise from truck and automobile traffic; ship loading cranes and related diesel-powered equipment; and continuously operating transmission lines for steam, fuel, water, and related pumping systems for those and other liquids. No ambient noise level increases are expected to occur as a result of any of the alternatives. Therefore, no noise impacts would be expected to occur.

5.1.2.11 Traffic and Transportation

Shipments of radioactive materials in the Naval Nuclear Propulsion Program are required to be made in accordance with applicable regulations of the U. S. Department of Transportation, U.S. Department of Energy, and the U.S. Nuclear Regulatory Commission. The purpose of these regulations is to ensure that shipments of radioactive material are adequately controlled to protect the environment and the health and safety of the general public. These regulations are applicable to all radioactive material shipments and provide requirements for the container design, certification, and identification as applicable for the specific quantity, type, and form of radioactive material being shipped. Naval shipping container design requirements invoke shielding and integrity specifications and meet all regulatory requirements. They provide for testing of container designs, training and qualification of workers who construct containers, and quality control inspections during fabrication to ensure that the containers will meet their design requirements. A detailed description of the shipping containers used for naval spent nuclear fuel shipments is provided in Attachment A. A description of the impacts associated with normal and accident conditions associated with transportation of naval spent nuclear fuel is provided in Attachment A.

5.1.2.11.1 Regional Infrastructure.

The alternatives under consideration are described in Section 3. The No Action alternative or the first variation of the Decentralization alternative would store the naval spent nuclear fuel on-site. This alternative would reduce the number of rail shipments from the shipyard or prototype site compared to the past practice of transporting all naval spent nuclear fuel to INEL. The second variation of the Decentralization alternative would ship about 10 percent of the naval spent nuclear fuel to Puget Sound. This would have some transportation impact, but not as much as transporting all naval spent nuclear fuel off-site. The third Decentralization alternative ships all naval spent nuclear fuel to INEL, examines it, and returns it to the original shipyard or prototype site. This alternative involves more transportation than the previous practice of transporting naval spent nuclear fuel to INEL, since the naval spent nuclear fuel is not returned from INEL to the original site. The 1992/1993 Planning Basis alternative, the Regionalization at INEL alternative, or the Centralization at INEL alternative would involve the same transportation as has been required in the past, namely transportation to INEL and retention there. The Centralization alternative at the Hanford Site would result in more transportation impact than any of the previous alternatives, due to the distances and population distribution between Hanford and the shipyards and prototypes. The Centralization alternative at the Savannah River Site would result in the most transportation impact of naval spent nuclear fuel of any of the alternatives.

5.1.2.11.2 Site Infrastructure.

If the alternative of storing naval spent nuclear fuel at Norfolk Naval Shipyard were to be selected, operation of a naval spent nuclear fuel storage facility would not noticeably affect site highway traffic because any increase in the work force would represent a very small incremental increase in overall traffic to and from the shipyard. Internal traffic in the Norfolk Naval Shipyard would increase in the short-term; however, the total impact on shipyard and surrounding area traffic would be very small.

5.1.2.12 Occupational and Public Health and Safety

Detailed analyses of incident-free naval spent nuclear fuel transportation and storage and handling impacts on worker and public health are described in Attachment A (transportation) and Attachment F (storage and inspection).
The transportation analysis results, and the storage and handling analysis are summarized separately in the following subsections.

5.1.2.12.1 Incident-free Transportation Occupational and Public Health and Safety.

The radiological and non-radiological health effects associated with the incident-free transportation of naval spent nuclear fuel and test specimens have been assessed for the general population, transportation workers, and hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancers as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. The details of the transportation analysis are provided in Attachment A.

5.1.2.12.2 Incident-free Occupational and Public Health and Safety During Naval Spent Nuclear Fuel Storage and Handling.

The public health and safety impacts of radioactivity releases and direct radiation from storage of naval spent nuclear fuel were analyzed as discussed in Section 5.1.2.7 and Attachment F. Attachment F summarizes the results of the analysis of radioactivity releases and direct radiation from stored naval spent nuclear fuel. This analysis shows that the exposure to the worker, maximally exposed off-site individual, and nearest public access from stored naval spent nuclear fuel would result in far less than one fatality per year. For perspective, it could be stated that one member of these population groups might experience a fatal cancer due to storage of naval spent nuclear fuel at Norfolk Naval Shipyard if operations continued for 7,100 years.

Projections of the number of occupational accidents that might occur during construction and operation of naval spent nuclear fuel storage and examination facilities have been made for each alternative. These projections are presented in Attachment F. Based on the results of these projections, it is concluded that the number of occupational fatalities and injuries or illnesses for construction activities and storage and examination operations would be very small for any alternative.

No public or occupational radiological health and safety impacts would be expected to result from naval spent nuclear fuel storage area construction activities since the construction would not involve radioactive work.

Attachment F also discusses toxic chemical issues for naval spent nuclear fuel handling and storage. Attachment F concludes that there would be no additional types or volumes of chemicals required at the shipyards or prototype site for naval spent nuclear fuel storage. Therefore, there is no incident-free non-radiological impact resulting from storage of naval spent nuclear fuel at the shipyards or prototype site.

5.1.2.12.3 Incident-free Occupational and Public Health and Safety Effects on Environmental Justice Due to Naval Spent Nuclear Fuel Storage and Handling.

As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from normal operations associated with the management of naval spent nuclear fuel at the Norfolk Naval Shipyard would be small under any of the alternatives considered. For example, it is unlikely that a single fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to normal operations or accident conditions for any of the alternatives considered present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is true for normal operations because the effects of routine operations are so small. It is also true for accident conditions because the consequences of any accident would depend on the random conditions at the time it occurred, and the wind directions at the Norfolk Naval Shipyard do not display any strongly dominant direction. Similarly, the conclusion is not affected by concerns related to subsistence consumption of fish or game since environmental monitoring in the vicinity of this relatively small and restricted site has shown no detectable difference in the amounts of radioactivity present in the environment from levels in similar parts of the region.

To place the impacts on environmental justice in perspective, the risk associated with routine naval spent nuclear fuel management operations under any of the alternatives considered would be less than one fatality per year for the entire population. For comparison, in 1990 there were approximately 510,000 cancer deaths in the United States population and there were about 64,000 cancer deaths among people of color in the U. S. Even if all of the impacts associated with one of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would be unlikely to experience a single additional cancer fatality in any year. Therefore, the cancer risk for that population from naval spent nuclear fuel management would not constitute a disproportionately high and adverse impact on human health or the environment. The same conclusion can be drawn for low-income groups.

5.1.2.13 Utilities and Energy

If an alternative associated with storage of spent nuclear fuel at Norfolk Naval Shipyard were to be selected, construction and operation of the storage facility would not be expected to require a large expenditure of utilities and energy resources. Construction activities would require quantities of water and electricity typical of any small to medium size construction project. Operation of a dry container spent fuel storage facility would likely require only a small amount of electricity for lighting and to support industrial equipment necessary to move spent nuclear fuel. Alternatives associated with water pool storage would require heating, ventilation, water, and electrical systems suitable for a work environment and to properly filter and exhaust the airborne discharges to the atmosphere. The utility and energy demands would be less than those required to operate ECF (10,000 MWh per year) (Section 5.2.13) since the water pool used for spent fuel storage would be smaller and no spent fuel operations beyond visual examinations would be conducted in the water pool.

The amount of utilities and energy expected to be consumed would be a small incremental increase in the total amount of utilities and energy used at the shipyard and would not result in any discernible environmental consequence.

5.1.2.14 Facility and Transportation Accidents

5.1.2.14.1 Facility Accidents. There has never been an accident in the history of the Naval

Nuclear Propulsion Program that resulted in a significant release of radioactivity to the environment or that resulted in radiation exposure to workers in excess of abnormal occurrence limits on exposures as defined by the U.S. Nuclear Regulatory Commission. A description of potential accidents considered and a summary of the accident analyses that were conducted with regards to the storage of naval spent nuclear fuel are contained in Attachment F.

5.1.2.14.1.1 Radiological Accidents. Section 3.7.3 provides a summary of the impacts

due to the most severe accidents considered for each site. The facility accident with the greatest potential impact at Norfolk Naval Shipyard involves an airplane crash. An accident of this magnitude would result in a calculated 16 fatal cancers to the general population over 50 years, as described in Attachment F. The likelihood of such an accident occurring is 1 x 10-6, which is very small. For perspective, an accident such as this would not be expected to occur unless the facility operated for about 1,000,000 years.

5.1.2.14.1.2 Non-radiological Accidents. As discussed in detail in Attachment F, the

limiting hypothetical non-radiological accident for naval spent nuclear fuel storage in a water pool at a shipyard or prototype location would be a diesel fuel spill and fire. A catastrophic failure of a diesel fuel storage tank that might be used for an emergency diesel generator to provide backup electrical power was postulated to occur, resulting in the spilling of the entire quantity of diesel fuel with a subsequent fire. The fire would generate the following toxic chemicals:

- Carbon monoxide
- Oxides of nitrogen (90% nitric oxide and 10% nitrogen dioxide)
- Lead
- Sulfur dioxide.

Measures would be taken to reduce the health impacts of potential releases of toxic materials. These measures would involve controls to protect both workers and the general public. The naval shipyard and prototype sites have emergency planning, emergency preparedness, and emergency response programs in place to protect both workers and the public, and involve established resources such as warning communications, fire departments, and emergency command centers.

The airborne concentrations of the combustion products listed above, resulting from the fire, were calculated at the locations of the on-site individuals, an individual at the site boundary, and the general population within a 50-mile radius of the facility. Detailed results are presented in Attachment F. If the accidental fire that has been hypothesized were to actually occur, the safety measures that would be in place would ensure no adverse health impacts to the general public and minimal health impacts to the workers.

5.1.2.14.2 Transportation Accidents.

Shipments of radioactive materials associated with naval spent nuclear fuel have never resulted in any measurable release of radioactivity to the environment (NNPP 1994a). There have never been any significant accidents involving release of radioactive material during shipment since the Naval Nuclear Propulsion Program began. The effects of potential transportation accidents during the various stages of transportation of naval spent nuclear fuel are presented in Attachment A.

The health effects associated with accidents during shipments of naval spent nuclear fuel and test specimens have been assessed for the general population and the hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancers as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. Details of the transportation analysis are provided in Attachment A.

5.1.2.14.3 Other Impacts of Accidents.

In addition to the possible human health effects associated with facility or transportation accidents described in the preceding sections, other effects such as the impacts on socioeconomics and land use in the area and the costs of cleanup have been estimated in order to develop a perspective and to evaluate potential differences among alternatives. The analyses described in Attachment F showed that an area ranging from about 8 acres extending approximately a quarter mile (for an inadvertent criticality accident) to about 110 acres extending approximately 0.9 mile (for a large airplane crashing into a dry storage container) might be contaminated to the point where exposure could exceed 100 millirem per year. Beyond these distances, the exposure would be less than 100 millirem per year, the Nuclear Regulatory Commission's standard for protection of the general population from radiation. Persons who live in this area might be evacuated or otherwise experience restrictions in their daily activities for a brief period, and those who work at locations within this area might be prevented from going to their jobs until measures had been taken to reduce the potential for exposure. It should be noted that all of the affected area within about a quarter of a mile from the spent nuclear fuel facility would be inside the boundaries of the federally owned site.

An accident might result in short-term restrictions on access to a relatively small area, but there would be no enduring impacts on cultural or similar resources, partially because the area involved would be small and partly because the remedial actions would be conducted in a careful, controlled manner in full compliance with applicable laws and regulations. The area impacted would vary only slightly among the alternatives. Overall, the risks are small so these considerations do not assist in distinguishing among alternatives.

Facility or transportation accidents associated with any of the alternatives would not have an appreciable effect on the ecology of the area, considering the potential for human health effects and the amount of land which might be affected, as described in earlier parts of this section. There is little consensus among scientists on methods for estimating the effects of radiation on ecological resources such as plant or animal life, but since human health effects for all the accidents analyzed are small and most plants and animals are not thought to be more sensitive to radiation than human beings, the small impacts on human health provide an indication that the impacts on animal and plant species in the area would also be small for all alternatives considered. Similarly, since the areas which might be contaminated to measurable levels by chemicals or radioactive material during the hypothetical accidents would be relatively small, any effects on the ecology would be limited to small areas. There are no endangered or threatened species unique to the area surrounding the federally owned site and an accident would not be expected to result in destruction of any species for any of the alternatives considered. The effects of accidents related to any of the alternatives and any associated cleanup which might be performed would be localized in a small area extending only a short distance beyond the boundaries of the federally owned site and would not be expected to appreciably affect threatened or endangered species in the area. Based on these considerations, evaluation of impacts of accidents on ecological resources does not help to distinguish among alternatives.

5.1.2.14.4 Effects of Accidents on Environmental Justice Due to Naval Spent Nuclear

Fuel Storage and Handling.

As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from facility or transportation accidents associated with the management of naval spent nuclear fuel at the Norfolk Naval Shipyard would be small under any of the alternatives considered. For example, it is unlikely that a single additional fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to an accident for any of the alternatives considered would present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects from accidents associated with the management of naval spent nuclear fuel would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is because the consequences of any accident would depend on the random conditions in effect at the time an accident occurred, and the wind directions at the Norfolk Naval Shipyard are highly variable with no strongly dominant direction.

To place the impacts on environmental justice in perspective, the risk associated with accidents caused by naval spent nuclear fuel management under any of the alternatives considered would amount to less than one additional fatality per year for the entire population. For comparison, in 1990 there were approximately 40,000 traffic fatalities in the United States population and there were about 7,400 deaths caused by traffic accidents among people of color in the U. S. Even if all of the additional cancer deaths associated with an accident involving any of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would experience less than one additional fatal cancer per year. The same conclusion can be drawn for low-income groups.

5.1.2.15 Waste Management

The alternative in which naval spent nuclear fuel is stored at Norfolk Naval Shipyard would produce limited amounts of solid municipal waste, solid low-level radioactive wastes, and hazardous wastes.
In addition, no transuranic or high-level radioactive wastes would be generated by spent nuclear fuel activities at the site under any alternative. The quantity of industrial wastes generated would be small and most likely consist of industrial cleaning agents of the type normally encountered at the site. Small quantities of sanitary wastes would result from the additional work force but this volume would be small. The wastes produced from the storage of naval spent nuclear fuel would be controlled and minimized in accordance with the existing waste management programs at the shipyard. The amount of additional wastes generated would be minimal compared to the existing baseline and would not cause any adverse impacts to public health and safety and the environment in the vicinity of the shipyard.

5.1.2.16 Cumulative Impacts

5.1.2.16.1 Radiological Cumulative Impacts. Spent nuclear fuel storage at the site would not

result in discharges of radioactivity in liquid effluents during routine operations regardless of the alternative selected. Therefore, there would be no incremental addition of radioactivity to surface or ground water as a result of normal operations for any alternative. For alternatives involving the storage of spent nuclear fuel in dry storage and shipping containers, no airborne radioactivity emissions are expected, so there would be no cumulative air quality impacts associated with these storage methods. Consequently, the only radiological cumulative impacts that would result from dry storage alternatives would be due to direct radiation exposure from the stored containers of spent nuclear fuel.

For alternatives involving the storage of naval spent nuclear fuel in water pools, there would be no discernible direct radiation exposure to the public from the fuel elements due to the shielding provided by the water in the pool. Therefore, any cumulative impacts which would result from water pool storage would be primarily due to airborne emissions, and the addition of these emissions would cause an indiscernible change in the emissions in the area (see Section 5.1.2.7). Current operations at the site are in compliance with Title 40, Code of Federal Regulations, Part 61, "National Emission Standards for Hazardous Air Pollutants." Cumulative air emissions would not threaten to exceed any applicable air quality requirement or regulation, either federal, state, or local in radiological and non-radiological categories.

A summary of the cumulative radiological impacts is provided in the following section.

An overview of the historical radiological impacts from naval nuclear operations at the Norfolk Naval Shipyard and from transportation of naval spent nuclear fuel is provided in Section

4.1.2.12 and detailed analyses are provided in Attachments F and A.

Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

The radiological impacts associated with the alternatives where naval spent nuclear fuel would be stored at Norfolk Naval Shipyard are very small and are described in Section 5.1.2.12, with the detailed results of analyses provided in Attachment F. In order to calculate cumulative impacts for the period between 1995 and 2035, the annual radiological impacts associated with each location and alternative were summed over 40 years. The results of this summation are tabulated in Tables 3-5 and 3-6 of Section 3.

The cumulative transportation impacts for the population groups from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated and are very small. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A and summarized in Section 3.7.4.

The total exposure to the population in the vicinity of the Norfolk Naval Shipyard from all of the alternatives considered would be approximately 11.2 person-rem. This means that there would be much less than one fatal cancer from these operations over the entire 40-year period evaluated. The total exposure to a theoretical maximally exposed off-site individual living at the shipyard boundary for the entire 40-year period would be 0.12 rem due to the alternative resulting in the largest exposure. This maximally exposed off-site individual would have a 6.0 x 10-5 risk of contracting a fatal cancer during his or her lifetime due to storage of spent nuclear fuel. When existing site radiological impacts due to naval nuclear operations are added to the impacts of the most limiting spent nuclear fuel alternative, the exposure to the population would be 13.6 person-rem and to the maximally exposed off-site individual would remain at 0.12 rem. This still results in much less than one fatal cancer in the population and the risk of the maximally exposed off-site individual contracting a fatal cancer during his or her lifetime is essentially unchanged.

The total exposure related to naval spent nuclear fuel activities to a worker assumed to be working continually 100 meters from the spent nuclear fuel under the alternative resulting in the largest exposure is 0.23 rem accumulated over 40 years. That corresponds to a fatal cancer risk of 9.2 x 10-5 during the worker's lifetime. The exposure to the same worker when existing site radiological impacts due to naval nuclear operations are added to the spent nuclear fuel exposure is 0.232 rem over 40 years which corresponds to a fatal cancer risk of 9.3 x 10-5 during the worker's lifetime. The impacts associated with transportation of naval spent nuclear fuel for all of the alternatives considered would be similarly low.

No contribution to cumulative impacts from accidents involving naval spent nuclear fuel has been included in the analyses presented in this Environmental Impact Statement because there has never been a nuclear reactor accident, criticality accident, transportation accident, or any release of radioactivity which had a significant effect on the environment.

Sections 4.1.2.14 and 5.1.2.15 describe the management of low-level radioactive waste and mixed waste at the site. The volume of low-level radioactive wastes which would be generated under the alternatives has not been calculated. However, considering the nature of radiological work that would be associated with spent nuclear fuel storage activities, the amount of low-level radioactive waste produced during spent nuclear fuel activities would be much less than 20 percent of the current site generation rate (1019 m3 per year). This additional radioactive waste would not introduce any changes to the site's waste management practices. The small amount of additional material involved would not impose any discernible additional stress on the capacity of the radioactive waste burial ground. Therefore, any cumulative impacts associated with the generation and disposal of additional low-level wastes would be very small.

Since no mixed, transuranic, or high-level radioactive wastes would be generated by spent nuclear fuel activities at this site under any alternative, there would be no cumulative impacts associated with these materials.

5.1.2.16.2 Non-radiological Cumulative Impacts.

An overview of the historical non-radiological impacts from naval nuclear operations at the Norfolk Naval Shipyard and from transportation of naval spent nuclear fuel is provided in Section 4.1.2.12 and detailed analyses are provided in Attachments F and A. Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no non-radiological cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

The non-radiological impacts associated with the alternative where naval spent nuclear fuel would be inspected or stored at Norfolk Naval Shipyard are described in Section 5.1.2.12, with the detailed results of analyses provided in Attachment F. As summarized in Section 5.1.2.12, there would be no additional chemicals required at the shipyard for naval spent nuclear fuel storage and therefore no non-radiological impacts from normal operations. Consequently, no cumulative impacts to air quality or water resources would result since the incremental addition of chemicals at the shipyard that might result from naval spent fuel activities would be very small. There are no current environmental problems associated with these materials.

The non-radiological cumulative transportation impacts for the population from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A. The non-radiological impacts associated with the transportation and storage of naval spent nuclear fuel for all of the alternatives considered would be low.

No cumulative land use impacts would be expected to occur as a result of spent nuclear fuel storage. The land that would be dedicated for this purpose is on existing federal property and situated in an industrial setting which has already been disturbed from its natural state (over 1100 acres are developed land). The conversion of this space for storage of spent nuclear fuel would not result in the need to disturb undeveloped land or for additional land to be added to the federally owned property in the foreseeable future.

From a socioeconomic perspective, the introduction of naval spent nuclear fuel activities at the site would create a small number of additional jobs and could have a very small cumulative socioeconomic impact. The site currently employs approximately 8500 civilian personnel. No shipyard employment has been associated with spent nuclear fuel activities in the past since spent nuclear fuel activities have not been conducted at the site. An average of approximately 1 to 40 additional jobs might be added as a result of possible spent nuclear fuel activities in the future. The peak number of additional jobs created at the site in any given year would be approximately 132, which is associated with construction and operation of a water pool facility for storage of spent nuclear fuel. Considering that the regional labor force consists of approximately 533,000 workers, the additional number of added jobs under any alternative would have little or no discernible socioeconomic impact. These jobs would be filled either from within the existing site work force or from the available regional labor force without discernible effect. There are no foreseeable future projects planned at the site and no known projects planned in the region that would cause the small number of workers involved in naval spent nuclear fuel activities to become an important impact.

The cumulative impacts associated with non-radiological waste management are likewise expected to be small. As stated previously, any industrial wastes generated from naval spent nuclear fuel storage would be small and limited to industrial cleaning agents of the type normally encountered at the site. The volume of municipal solid wastes and sanitary wastes which would be generated is expected to be proportional to the number of additional workers added, and this small incremental increase would not be discernible. The amount of additional non-radiological wastes generated would not introduce any changes to the site's waste management practices and would not impose any additional stress on the capacity of on-site or off-site waste disposal or treatment facilities. Therefore, any cumulative impacts associated with the generation and disposal of additional wastes would be very small. There are no current environmental problems associated with these types of waste.

5.1.2.17 Unavoidable Adverse Effects

There are no discernible unavoidable adverse effects associated with the implementation of any of the alternatives and none which would help to choose among the alternatives. The alternative in which naval spent nuclear fuel is stored at the Norfolk Naval Shipyard would cause the public to be exposed to small amounts of radiation, described in Section 5.1.2.12, and would result in less than one health effect in the entire population surrounding the shipyard. Similarly, continued operation of the storage facility would produce limited amounts of solid municipal waste and solid low-level radioactive waste. These amounts of waste would not produce any major impacts in the vicinity of the shipyard. There will be no changes to the ecological, cultural, geological, and aesthetic resources due to the implementation of any of the alternatives. There would also be no expected impact on ambient noise levels.

5.1.2.18 Irreversible and Irretrievable Commitments of Resources

The only irreversible and irretrievable commitment of resources that results from the alternative in which naval spent nuclear fuel would be stored at the Norfolk Naval Shipyard would be the money which would be spent by the federal government to construct the necessary facilities. The total cost of storing spent naval nuclear fuel at the shipyards and prototype ranges from approximately $1.5 billion to $5.7 billion. This cost represents the total cumulative cost over the 40-year period for all of the shipyards and prototype. This cost includes construction costs of the new storage facilities, and, depending on the alternative selected, the operation of a limited examination facility at Puget Sound Naval Shipyard combined with the costs associated with shutting down ECF, or the operational costs of the INEL-ECF. The major expense in the highest cost alternatives is the procurement of shipping containers. Refer to Section 3.7 for a comparison of the total cumulative costs among alternatives.

5.1.3 PORTSMOUTH NAVAL SHIPYARD: KITTERY, MAINE

5.1.3.1 Overview of Environmental Impacts

The following sections discuss the major differences in potential environmental consequences associated with the choice of alternatives that include storage of naval spent nuclear fuel at Portsmouth Naval Shipyard. The environmental consequences associated with storage of naval spent nuclear fuel at Portsmouth Naval Shipyard are based on the estimates of naval spent nuclear fuel that will be stored at Portsmouth Naval Shipyard through the year 2035 and current knowledge of the design features associated with spent fuel shipping containers, immobile storage containers, and storage systems. The review of the environmental consequences associated with each of these alternatives has shown that the associated impact on the environment is very small. There would be no impact to the Portsmouth Naval Shipyard regional environment associated with any alternatives that do not involve the Portsmouth Naval Shipyard.

5.1.3.2 Land Use

Construction of a storage area at Portsmouth Naval Shipyard would require a modest change in the current land use by the shipyard. A description of the alternative storage containers and their approximate storage locations is provided in Attachment D. Attachment C provides a comparison of spent nuclear fuel storage in new water pools versus dry container storage.

The alternative of storing naval spent nuclear fuel in water pools would require that a water pool facility be constructed in the vicinity of the area that is designated for dry container storage. The water pool would have sufficient capacity to accommodate storage of all naval spent nuclear fuel expected to be stored at the shipyard.

No additional land outside the shipyard would be required.

Native American rights and interests would not be modified by construction or operations associated with any of the alternatives considered.

5.1.3.3 Socioeconomics

The calculated number of direct construction and operating jobs that would be required for the 10-year period between 1995 and 2004 for each storage alternative at the shipyard is provided in **Table 5.1.3-1.** Since there would be no naval spent nuclear fuel storage or inspection activities at the shipyard under the 1992/1993 Planning Basis and Centralization alternatives, no additional jobs would be required at the shipyard under these alternatives.

Table 5.1.3-1. Number of construction and operating jobs created at Portsmouth Naval Shipyard for each alternative.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Railcar(1)	1	1	6	1	1	1	1	1	1	1
Immobile Containers on Pads(2)	1	1	1	1	2	6(3)	4	4	4	4
Shipping Containers on Pads (2)	1	1	1	1	2	6(3)	1	1	1	1
Water Pools(2)	16	16	47	72	89	63	77	35	35	35

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(1) Storage mode under the No Action and Decentralization alternatives.
(2) Storage mode under the Decentralization alternative.
(3) The construction jobs would last less than one year.

The only discernible socioeconomic consequence of storing naval spent nuclear fuel at Portsmouth Naval Shipyard is that a relatively small number of construction workers (ranging from a few to a maximum of several hundred would be required for construction of the area). The work force would consist of skilled craftsmen and unskilled laborers. This work force would be needed during the storage facility construction and would be available from within the area.

The operation of the spent fuel storage area using dry storage containers would require additional workers to secure the fuel in the storage area and to support surveillance and monitoring activities. For the alternative involving storing fuel in immobile dry storage containers, about 20 workers would be required to handle the spent nuclear fuel when it is placed into the storage containers. This work force would normally only be needed when fuel is being inserted into the containers. For the alternative involving shipping containers, fewer workers would be needed to handle and secure the containers in the storage area. The operation of a water pool facility for the alternative involving storing naval spent nuclear fuel in a water pool would require approximately 40 additional workers. The number required for any of the shipyard and prototype site storage alternatives would be small and is expected to be supplied from either within the existing shipyard work force or from the local work force. Considering that the shipyard employs approximately 5000 naval and civilian personnel, the addition of workers to support the alternatives would have no discernible impact on the local socioeconomic conditions of the Portsmouth Naval Shipyard site.

For the alternatives where dry storage containers would be manufactured, some additional jobs would be created in the locations where the containers are made. The process of selecting the container manufacturer is subject to federal procurement requirements and would be initiated after the Record of Decision. Consequently, the specific socioeconomic impacts from container fabrication cannot be specified. The net effect of container fabrication would be to create additional jobs and bolster the local economy of the area(s) where containers are made. It is considered unlikely that the selection of the contractor would depend on the alternative storage site selected, so the jobs associated with construction of casks provide no basis for selection of a storage site.

5.1.3.4 Cultural Resources

All construction contracts for the shipyard contain a clause such that if artifacts are uncovered, appropriate measures must be taken to ensure the safe recovery of such items. In most cases, these items are then placed in the shipyard museum.

The shipyard's historic district is considered a valued cultural resource and many buildings are listed on the historic register. The implementation of storage alternatives will not affect any site that is listed on the National Register of Historic Places (NPS 1991), any known archaeological areas, or any other cultural resources. Therefore, there would be no impacts to cultural resources associated with the alternative of storing naval spent nuclear fuel at the shipyard.

None of the alternatives considered would impact known archaeological or Native American sites. Procedures which comply with all applicable laws and regulations would be implemented to protect previously undetected archaeological and cultural sites.

5.1.3.5 Aesthetic and Scenic Resources

The naval spent nuclear fuel storage area would be located within the Portsmouth Naval Shipyard which is an existing industrial setting and would not affect the visual quality of the area since it is compatible with the landscape character of the site. Physical changes to the site resulting from the construction of a naval spent nuclear fuel storage facility will not alter this setting. There are no particulate air emissions associated with storage of naval spent nuclear fuel and thus no visibility impacts are expected. No aesthetic or scenic resources in the vicinity of the shipyard would be affected by the construction and operation of the storage facility.

5.1.3.6 Geology

If an alternative were to be selected which required naval spent nuclear fuel to be stored at Portsmouth Naval Shipyard, the construction and operation of the naval spent nuclear fuel storage facility would not be expected to affect the geologic character or resources of the region. During the storage facility construction phase, the ground would need to be excavated as necessary to prepare the surface. This would not affect the geological characteristics of the underlying layers. For the alternative of storing naval spent nuclear fuel in a storage pool facility, the ground surface would need to be excavated to a depth of approximately 40 feet. This excavation would not affect the geological characteristics of the area.

5.1.3.7 Air Resources

5.1.3.7.1 Radiological Consequences.

No airborne radionuclide releases from normal operations are expected to occur as a result of the alternatives involving naval spent nuclear fuel being stored in dry storage containers. The fuel would be contained such that at least two barriers exist to prevent fission products from becoming airborne. These barriers would retain the spent nuclear fuel in an air-tight containment until moved to a permanent storage site and there would be no airborne radioactive material released from routine operations for this method of storage. The only radiation exposure would be direct radiation from the array of filled storage containers. The filled storage containers would be fenced off and shielded if necessary such that there would be no distinguishable effect on the current radiation readings at the site perimeter.

For the alternative where naval spent nuclear fuel would be stored in a water pool, airborne radionuclide releases are expected to be less than the emissions from the Idaho National Engineering Laboratory (INEL) Expended Core Facility (ECF) because the water pool size and number of inspections performed would be smaller at the shipyard and the shipyard would not conduct the shielded cell operations that are performed at ECF. To conservatively estimate the radiological consequences, airborne releases based on ECF releases from 1991 are used. The radiological source term used and the detailed calculations performed to determine expected normal releases are provided in Attachment F.

The radiation exposures to human beings due to estimated radionuclide releases to the atmosphere plus direct radiation from the stored spent nuclear fuel at the shipyards for both the alternative involving water pool storage and the alternative involving dry storage were calculated as described in Attachment F.

A person on the shipyard boundary at the location where the largest exposures would be received was used as the hypothetical maximally exposed off-site individual (MOI) for postulated releases of radioactive material from the stored fuel. The population data used to calculate population exposures were taken from 1990 census data provided by the U.S. Census Bureau. Meteorology data were obtained as described in Attachment F. Estimated exposures to workers were also calculated.

The hypothetical exposures calculated are based on an exposure to the estimated average effluents and the direct radiation exposure for one year from the fuel stored at the shipyard. The calculations include the external effective equivalent exposure from the ground deposition, deposition to surface water, and air immersion pathways and the 50-year committed effective equivalent exposure from internal exposure through the ingestion and inhalation pathways. All pathways were considered for persons potentially exposed, except that the ingestion pathway was omitted for the workers because they do not grow their food on-site. Solubilities which would produce the highest calculated exposures were chosen for internal exposure factors. Values for human dietary consumption patterns were taken from "Age Dependent Values of Dietary Intake for Assessing Human Exposures to Environmental Pollutants" (Rupp 1980). The hypothetical exposures calculated can be converted into a risk of fatal cancer or a risk of non-fatal health detriments (e.g., non-fatal cancers, hereditary defects) based on the "1990 Recommendations of the International Commission on Radiological Protection" (ICRP 1991).

Attachment F summarizes the calculated exposures and fatal cancers to the worker, maximally exposed off-site individual (MOI), nearest public access (NPA), and the population from releases of radioactivity and direct radiation exposure in one year for each location and storage mode. Section 3.7 provides a comparison of the annual number of fatal cancers calculated for the general population for each location and alternative.

The number of fatal cancers calculated is so small that there would be essentially no fatal cancers resulting from the storage of naval spent nuclear fuel during the time it could reasonably be expected to continue to be stored. Putting this into perspective, it could be stated that one member of the population might experience a fatal cancer due to incident-free storage of naval spent nuclear fuel at the Portsmouth Naval Shipyard if operations continued for 43,500 years.

If a water pool facility would be constructed at the Portsmouth Naval Shipyard and used for storage of naval spent nuclear fuel, the airborne emissions from the facility would be less than that identified for the Puget Sound Naval Shipyard because no naval spent nuclear fuel inspection operations beyond visual examination would be conducted in the water pool facility.

5.1.3.7.2 Non-radiological Consequences.

As noted in Attachment F, no increase in non-radioactive airborne emissions would be expected to result from spent nuclear fuel storage facility operations. Storage facility operations would not involve use of carcinogenic toxins, criteria pollutants, or other hazardous or toxic chemicals except that small quantities of industrial cleaning agents and paint thinner may be used for housekeeping and cleanliness control and these would be the same as those already used at the shipyard. Consequently, there would be no impact on ambient air quality as a result of implementing any of the alternatives at the shipyard.

If an alternative were to be selected that required a storage facility to be constructed or renovated, fugitive dust emissions would be expected to result from excavation operations. The quantity of dust generated would be small, consistent with typical excavation activities, and controlled within local requirements for dust control.

5.1.3.8 Water Resources

5.1.3.8.1 Radiological Consequences.

Spent nuclear fuel storage at the shipyard would not result in discharges of radioactivity to liquid effluents during routine operation regardless of the alternative selected for storage of spent nuclear fuel. The health effect due to fallout of nuclides released to the air onto the surface water is included in the analysis results discussed in Section 5.1.3.7. The air fallout impact is so small that there would be no distinguishable radiation levels in the water.

Portsmouth Naval Shipyard does not reside in the 100 or 500 year floodplain. Consequently, the floodplain would not be impacted by spent naval nuclear fuel storage and examination activities at the shipyard.

5.1.3.8.2 Non-radiological Consequences.

Other than chemicals used to maintain the storage area, no hazardous wastes would be generated by the storage of naval spent nuclear fuel at Portsmouth Naval Shipyard. Any hazardous liquid effluents that may be generated at the storage area would be disposed of at an Environmental Protection Agency approved disposal site.

The only source for liquid discharges from the naval spent nuclear fuel storage operations to the environment consists of storm water runoff which would be consistent with the type of discharges associated with common light industrial facilities and related activities. It can be concluded that there would be no impact to the human environment due to runoff water from the proposed naval spent nuclear fuel storage area.

The increased water usage under any alternative would be negligible compared to the existing shipyard demand.

5.1.3.9 Ecological Resources

Both Maine and New Hampshire officials were consulted and have determined that there is no evidence to suggest that any threatened or endangered species reside on the Portsmouth Naval Shipyard (Appendix V.B. of the Navy's Natural Resources Management Plan (Navy 1993)). No major changes to the industrial environment are planned. None of the alternatives would affect the areas surrounding the shipyard. Therefore, no major ecological impacts to the region would result from selection of any of the alternatives.

The conceptual location where naval spent nuclear fuel would be stored is illustrated in Attachment D. This location is within an existing industrial complex and is surrounded by buildings and paved areas. The industrial nature of the shipyard and the fact that the land has already been disturbed from its natural state by earlier activities mean that plant or animal species sensitive to disturbance by human activities would not be expected to be present. Therefore, there would be no ecological impacts associated with construction or operation of a spent nuclear fuel storage area at this location. The radiological controls that are in effect at the shipyard ensure that the radiation levels in the vicinity of the shipyard are maintained at or near natural background. Since these same controls would be applied to spent nuclear fuel activities, no ecological effects due to radioactive material would be expected to occur.

5.1.3.10 Noise

Portsmouth Naval Shipyard is an existing industrial-type environment characterized by noise from truck and automobile traffic; ship loading cranes and related diesel-powered equipment; and continuously operating transmission lines for steam, fuel, water, and related pumping systems for those and other liquids. No ambient noise level increases are expected to occur as a result of any of the alternatives. Therefore, no noise impacts would be expected to occur.

5.1.3.11 Traffic and Transportation

Shipments of radioactive materials in the Naval Nuclear Propulsion Program are required to be made in accordance with applicable regulations of the U. S. Department of Transportation, U.S. Department of Energy, and the U.S. Nuclear Regulatory Commission. The purpose of these regulations is to ensure that shipments of radioactive material are adequately controlled to protect the environment and the health and safety of the general public. These regulations are applicable to all radioactive material shipments and provide requirements for the container design, certification, and identification as applicable for the specific quantity, type, and form of radioactive material being shipped. Naval shipping container design requirements invoke shielding and integrity specifications and meet all regulatory requirements. They provide for testing of container designs, training and qualification of workers who construct containers, and quality control inspections during fabrication to ensure that the containers will meet their design requirements. A detailed description of the shipping containers used for naval spent nuclear fuel shipments is provided in Attachment A. A description of the impacts associated with normal and accident conditions associated with transportation of naval spent nuclear fuel is provided in Attachment A.

5.1.3.11.1 Regional Infrastructure.

The alternatives under consideration are described in Section 3. The No Action alternative or the first variation of the Decentralization alternative would store the spent nuclear fuel on-site. This alternative would reduce the number of rail shipments from the shipyard or prototype site compared to the past practice of transporting all spent nuclear fuel to INEL. The second variation of the Decentralization alternative would ship about 10 percent of the spent nuclear fuel to Puget Sound. This would have some transportation impact, but not as much as transporting all spent nuclear fuel off-site. The third Decentralization alternative ships all spent nuclear fuel to INEL, examines it, and returns it to the original shipyard or prototype site. This alternative involves more transportation than the previous practice of transporting spent nuclear fuel to INEL, since the spent nuclear fuel is not returned from INEL to the original site. The 1992/1993 Planning Basis alternative, the Regionalization at INEL alternative, or the Centralization at INEL alternative would involve the same transportation as has been required in the past, namely transportation to INEL and retention there. The Centralization alternative at the Hanford Site would result in more transportation impact than any of the previous alternatives, due to the distances and population distribution between Hanford and the shipyards and prototypes. The Centralization alternative at the Savannah River Site would result in the most transportation impact of spent nuclear fuel of any of the alternatives.

5.1.3.11.2 Site Infrastructure.

The alternative associated with naval spent nuclear fuel storage at Portsmouth Naval Shipyard would not noticeably affect site highway traffic because any increase in the work force would represent a very small incremental increase in overall traffic to and from the shipyard. There would be no noticeable change in the internal traffic in the shipyard because fuel is held temporarily even when it is transported off-site.

5.1.3.12 Occupational and Public Health and Safety

Detailed analyses of incident-free spent nuclear fuel transportation and storage and handling impacts on worker and public health are described in Attachment A (transportation) and Attachment F (storage and inspection). The transportation analysis results, and the storage and handling analysis are summarized separately in the following subsections.

5.1.3.12.1 Incident-free Transportation Occupational and Public Health and Safety.

The radiological and non-radiological health effects associated with the incident-free transportation of naval spent nuclear fuel and test specimens have been assessed for the general population, transportation workers, and hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancers as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. The details of the transportation analysis are provided in Attachment A.

5.1.3.12.2 Incident-free Occupational and Public Health and Safety During Spent Nuclear

Fuel Storage and Handling.

The public health and safety impacts of radioactivity releases and direct radiation from storage of spent nuclear fuel were analyzed as discussed in Section 5.1.3.7 and Attachment F. Attachment F summarizes the results of the analysis of radioactivity releases and direct radiation from stored spent nuclear fuel. This analysis shows that the exposure to the worker, maximally exposed off-site individual, and nearest public access from stored naval spent nuclear fuel would result in far less than one fatality per year. For perspective, it could be stated that one member of these population groups might experience a fatal cancer due to storage of naval spent nuclear fuel at Portsmouth Naval Shipyard if operations continued for 43,500 years.

Projections of the number of occupational accidents that might occur during construction and operation of naval spent nuclear fuel storage and examination facilities have been made for each alternative. These projections are presented in Attachment F. Based on the results of these projections, it is concluded that the number of occupational fatalities and injuries or illnesses for construction activities and storage and examination operations would be very small for any alternative.

No public or occupational radiological health and safety impacts would be expected to result from naval spent nuclear fuel storage area construction activities since the construction would not involve radioactive work.

Attachment F also discusses toxic chemical issues for spent nuclear fuel handling and storage. Attachment F concludes that there would be no additional types or volumes of chemicals required at the shipyards or prototype site for spent nuclear fuel storage. Therefore, there is no incident-free non-radiological impact resulting from storage of spent nuclear fuel at the shipyards or prototype site.

5.1.3.12.3 Incident-free Occupational and Public Health and Safety Effects on Environmental Justice Due to Naval Spent Nuclear Fuel Storage and Handling.

As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from normal operations associated with the management of naval spent nuclear fuel at the Portsmouth Naval Shipyard would be small under any of the alternatives considered. For example, it is unlikely that a single fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to normal operations or accident conditions for any of the alternatives considered present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is true for normal operations because the effects of routine operations are so small. It is also true for accident conditions because the consequences of any accident would depend on the random conditions at the time it occurred, and the wind directions at the Portsmouth Naval Shipyard do not display any strongly dominant direction. Similarly, the conclusion is not affected by concerns related to subsistence consumption of fish or game since environmental monitoring in the vicinity of this relatively small and restricted site has shown no detectable difference in the amounts of radioactivity present in the environment from levels in similar parts of the region.

To place the impacts on environmental justice in perspective, the risk associated with routine naval spent nuclear fuel management operations under any of the alternatives considered would be less than one fatality per year for the entire population. For comparison, in 1990 there were approximately 510,000 cancer deaths in the United States population and there were about 64,000 cancer deaths among people of color in the U. S. Even if all of the impacts associated with one of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would be unlikely to experience a single additional cancer fatality in any year. Therefore, the cancer risk for that population from naval spent nuclear fuel management would not constitute a disproportionately high and adverse impact on human health or the environment. The same conclusion can be drawn for low-income groups.

5.1.3.13 Utilities and Energy

If an alternative associated with the storage of naval spent nuclear fuel at Portsmouth Naval Shipyard were to be selected, construction and operation of the storage area would not be expected to require a large expenditure of utilities and energy resources. Construction activities will require quantities of water and electricity typical of any small to medium size construction project. Operation of the dry container naval spent nuclear fuel storage facility will likely require only a small amount of electricity for security lighting and to support industrial equipment necessary to move naval spent nuclear fuel (cranes, etc). Alternatives associated with water pool storage would require heating, ventilation, water, and electrical systems suitable for a work environment and to properly filter and exhaust the airborne discharges to the atmosphere. The utility and energy demands would be less than those required to operate ECF (10,000 MWh per year) (Section 5.2.13) since the water pool used for naval spent nuclear fuel storage would be smaller and no spent fuel operations beyond visual examinations would be conducted in the water pool.

The amount of utilities and energy expected to be consumed would be a small incremental increase in the total amount of utilities and energy used at the Portsmouth Naval Shipyard and will not result in any discernible environmental consequence.

5.1.3.14 Facility and Transportation Accidents

5.1.3.14.1 Facility Accidents. There has never been an accident in the history of the Naval

Nuclear Propulsion Program that resulted in a significant release of radioactivity to the environment or that resulted in radiation exposure to workers in excess of abnormal occurrence limits on exposures as defined by the U.S. Nuclear Regulatory Commission. A description of potential accidents considered and a summary of the accident analyses that were conducted with regards to the storage of naval spent nuclear fuel are contained in Attachment F.

5.1.3.14.1.1 Radiological Accidents. Section 3.7.3 provides a summary of the impacts

due to the most severe accidents considered for each site. The facility accident with the greatest potential impact at Portsmouth Naval Shipyard involves an airplane crash. An accident of this magnitude would result in 9 fatal cancers to the general population over 50 years, as described in Attachment F. The likelihood of an airplane crash is 1 x 10-7. The facility accident with the greatest risk involves accidental drainage of the water pool. The drained water pool accident would result in less than one fatality over 50 years, but the likelihood of occurrence is 1 x 10-5.

5.1.3.14.1.2 Non-radiological Accidents. As discussed in detail in Attachment F, the limiting

hypothetical non-radiological accident for spent nuclear fuel storage in a water pool at a shipyard or prototype location would be a diesel fuel spill and fire. A catastrophic failure of a diesel fuel storage tank that might be used for an emergency diesel generator to provide backup electrical power was postulated to occur, resulting in the spilling of the entire quantity of diesel fuel with a subsequent fire.

The fire would generate the following toxic chemicals:

- Carbon monoxide
- Oxides of nitrogen (90% nitric oxide and 10% nitrogen dioxide)
- Lead
- Sulfur dioxide.

Measures would be taken to reduce the health impacts of potential releases of toxic materials. These measures would involve controls to protect both workers and the general public. The naval shipyard and prototype sites have emergency planning, emergency preparedness, and emergency response programs in place to protect both workers and the public and involve established resources such as warning communications, fire departments, and emergency command centers.

The airborne concentrations of the combustion products listed above, resulting from the fire, were calculated at the locations of the on-site individuals, an individual at the site boundary, and the general population within a 50-mile radius of the facility. Detailed results are presented in

Attachment F. If the accidental fire that has been hypothesized were to actually occur, the safety measures that would be in place would ensure no adverse health impacts to the general public and minimal health impacts to the workers.

5.1.3.14.2 Transportation Accidents.

Shipments of radioactive materials associated with naval spent nuclear fuel have never resulted in any measurable release of radioactivity to the environment (NNPP 1994a). There have never been any significant accidents involving the release of radioactive material during shipment since the Naval Nuclear Propulsion Program began. The effects of potential transportation accidents during the various stages of transportation of naval spent nuclear fuel are presented in Attachment A.

The health effects associated with accidents during shipments of naval spent nuclear fuel and test specimens have been assessed for the general population and the hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancers as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. The details of the transportation analysis are provided in Attachment A.

5.1.3.14.3 Other Impacts of Accidents.

In addition to the possible human health effects associated with facility or transportation accidents described in the preceding sections, other effects such as the impacts on socioeconomics and land use in the area and the costs of cleanup have been estimated in order to develop a perspective and to evaluate potential differences among alternatives.
The analyses described in Attachment F showed that an area ranging from about 8 acres extending approximately a quarter mile (for an inadvertent criticality accident) to about 110 acres extending approximately 0.9 mile (for a large airplane crashing into a dry storage container) might be contaminated to the point where exposure could exceed 100 millirem per year. Beyond these distances, the exposure would be less than 100 millirem per year, the Nuclear Regulatory Commission's standard for protection of the general population from radiation. Persons who live in this area might be evacuated or otherwise experience restrictions in their daily activities for a brief period, and those who work at locations within this area might be prevented from going to their jobs until measures had been taken to reduce the potential for exposure. It should be noted that all of the affected area within about a quarter mile from the spent nuclear fuel facility would be inside the boundaries of the federally owned site.

An accident might result in short-term restrictions on access to a relatively small area, but there would be no enduring impacts on cultural or similar resources, partially because the area would be small and partly because all remedial actions would be conducted in a careful, controlled manner in full compliance with applicable laws and regulations. The area impacted would vary only slightly among the alternatives considered. Overall, the risks are small so these considerations do not assist in distinguishing among alternatives.

Facility or transportation accidents associated with any of the alternatives would not have an appreciable effect on the ecology of the area, considering the potential for human health effects and the amount of land which might be affected, as described in earlier parts of this section. There is little consensus among scientists on methods for estimating the effects of radiation on ecological resources such as plant or animal life, but since human health effects for all the accidents analyzed are small and most plants and animals are not thought to be more sensitive to radiation than human beings, the small impacts on human health provide an indication that the impacts on animal and plant species in the area would also be small for all alternatives considered. Similarly, since the areas which might be contaminated to measurable levels by chemicals or radioactive material during the hypothetical accidents would be relatively small, any effects on the ecology would be limited to small areas. There are no endangered or threatened species unique to the area surrounding the federally owned site, so an accident would not be expected to result in destruction of any species for any of the alternatives considered. The effects of accidents related to any of the alternatives and any associated cleanup which might be performed would be localized in a small area extending only a short distance beyond the boundaries of the federally owned site and thus would not be expected to appreciably affect the potential for survival of endangered or threatened species in southeastern Maine or New Hampshire. Based on these considerations, evaluation of impacts of accidents on ecological resources does not help to distinguish among alternatives.

5.1.3.14.4 Effects of Accidents on Environmental Justice Due to Naval Spent Nuclear

Fuel Storage and Handling.

As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from facility or transportation accidents associated with the management of naval spent nuclear fuel at the Portsmouth Naval Shipyard would be small under any of the alternatives considered. For example, it is unlikely that a single additional fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to an accident for any of the alternatives considered would present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects from accidents associated with the management of naval spent nuclear fuel would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is because the consequences of any accident would depend on the random conditions in effect at the time an accident occurred, and the wind directions at the Portsmouth Naval Shipyard are highly variable with no strongly dominant direction.

To place the impacts on environmental justice in perspective, the risk associated with accidents caused by naval spent nuclear fuel management under any of the alternatives considered would amount to less than one additional fatality per year for the entire population. For comparison, in 1990 there were approximately 40,000 traffic fatalities in the United States population and there were about 7,400 deaths caused by traffic accidents among people of color in the U. S. Even if all of the additional cancer deaths associated with an accident involving any of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would experience less than one additional fatal cancer per year. The same conclusion can be drawn for low-income groups.

5.1.3.15 Waste Management

The alternative in which naval spent nuclear fuel is stored at Portsmouth Naval Shipyard would produce limited amounts of solid municipal waste, solid low-level radioactive wastes, and hazardous wastes.

In addition, no transuranic or high-level radioactive wastes would be generated by spent nuclear fuel activities at the site under any alternative. The quantity of industrial wastes generated would be small and most likely consist of industrial cleaning agents of the type normally encountered at the site. Small quantities of sanitary wastes would result from the additional work force but this volume would be small. The wastes produced from the storage of naval spent nuclear fuel would be controlled and minimized in accordance with the existing waste management programs at the Portsmouth Naval Shipyard. The amount of additional wastes generated would be minimal compared to the existing baseline and would not cause any adverse impacts to public health and safety and the environment in the vicinity of the Portsmouth Naval Shipyard.

5.1.3.16 Cumulative Impacts

5.1.3.16.1 Radiological Cumulative Impacts. Spent nuclear fuel storage at the site would not

result in discharges of radioactivity in liquid effluents during routine operations regardless of the alternative selected. Therefore, there would be no incremental addition of radioactivity to surface or ground water as a result of normal operations for any alternative. For alternatives involving the storage of spent nuclear fuel in dry storage and shipping containers, no airborne radioactivity emissions are expected, so there would be no cumulative air quality impacts associated with these storage methods. Consequently, the only radiological cumulative impacts that would result from dry storage alternatives would be due to direct radiation exposure from the stored containers of spent nuclear fuel.

For alternatives involving the storage of naval spent nuclear fuel in water pools, there would be no discernible direct radiation exposure to the public from the fuel elements due to the shielding provided by the water in the pool. Therefore, any cumulative impacts which would result from water pool storage would be primarily due to airborne emissions, and the addition of these emissions would cause an indiscernible change in the emissions in the area (see Section 5.1.3.7). Current operations at the site are in compliance with Title 40, Code of Federal Regulations, Part 61, "National Emission Standards for Hazardous Air Pollutants." Cumulative air emissions would not threaten to exceed any applicable air quality requirement or regulation, either federal, state, or local in radiological and non-radiological categories.

A summary of the cumulative radiological impacts is provided in the following section.

An overview of the historical radiological impacts from naval nuclear operations at the Portsmouth Naval Shipyard and from transportation of naval spent nuclear fuel is provided in Section 4.1.3.12 and detailed analyses are provided in Attachments F and A. Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

The radiological impacts associated with the alternatives where naval spent nuclear fuel would be stored at Portsmouth Naval Shipyard are very small and are described in Section 5.1.3.12, with the detailed results of analyses provided in Attachment F. In order to calculate cumulative impacts for the period between 1995 and 2035, the annual radiological impacts associated with each location and alternative were summed over 40 years. The results of this summation are tabulated in Tables 3-5 and 3-6 of Section 3.

The cumulative transportation impacts for the population groups from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated and are very small. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A and summarized in Section 3.7.4.

The total exposure to the population in the vicinity of the Portsmouth Naval Shipyard from all of the alternatives considered would be approximately 1.8 person-rem. This means that there would be much less than one fatal cancer from these operations over the entire 40-year period evaluated. The total exposure to a theoretical maximally exposed off-site individual living at the shipyard boundary for the entire 40-year period would be 2.2 x 10-3 rem due to the alternative resulting in the largest exposure. This maximally exposed off-site individual would have a 1.1 x 10-6 risk of contracting a fatal cancer during his or her lifetime due to storage of spent nuclear fuel. When existing site radiological impacts due to naval nuclear operations are added to the impacts of the most limiting spent nuclear fuel alternative, the exposure to the population would be 2.2 person-rem and to the maximally exposed off-site individual would be 2.5 x 10-3 rem. This still results in much less than one fatal cancer in the population and the risk of the maximally exposed off-site individual contracting a fatal cancer during his or her lifetime is 1.3 x 10-6.

The total exposure related to naval spent nuclear fuel activities to a worker assumed to be working continually 100 meters from the spent nuclear fuel under the alternative resulting in the largest exposure is 0.11 rem accumulated over 40 years. That corresponds to a fatal cancer risk of 4.4 x 10-5 during the worker's lifetime. The exposure to the same worker when existing site radiological impacts due to naval nuclear operations are added to the spent nuclear fuel exposure is essentially the same over 40 years. The impacts associated with transportation of naval spent nuclear fuel for all of the alternatives considered would be similarly low.

No contribution to cumulative impacts from accidents involving naval spent nuclear fuel has been included in the analyses presented in this Environmental Impact Statement because there has never been a nuclear reactor accident, criticality accident, transportation accident, or any release of radioactivity which had a significant effect on the environment.

Sections 4.1.3.14 and 5.1.3.15 describe the management of low-level radioactive waste and mixed waste at the site. The volume of low-level radioactive wastes which would be generated under the alternatives has not been calculated. However, considering the nature of radiological work that would be associated with spent nuclear fuel storage activities, the amount of low-level radioactive waste produced during spent nuclear fuel activities would be much less than 20 percent of the current site generation rate (57 m3 per year). This additional radioactive waste would not introduce any changes to the site's waste management practices. The small amount of additional material involved would not impose any discernible additional stress on the capacity of the radioactive waste burial ground. Therefore, any cumulative impacts associated with the generation and disposal of additional low-level wastes would be very small.

Since no mixed, transuranic, or high-level radioactive wastes would be generated by spent nuclear fuel activities at this site under any alternative, there would be no cumulative impacts associated with these materials.

5.1.3.16.2 Non-radiological Cumulative Impacts.

An overview of the historical non-radiological impacts from naval nuclear operations at the Portsmouth Naval Shipyard and from transportation of naval spent nuclear fuel is provided in Section 4.1.3.12 and detailed analyses are provided in Attachments F and A. Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no non-radiological cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

The non-radiological impacts associated with the alternative where naval spent nuclear fuel would be inspected or stored at Portsmouth Naval Shipyard are described in Section 5.1.3.12, with the detailed results of analyses provided in Attachment F. As summarized in Section 5.1.3.12, there would be no additional chemicals required at the shipyard for naval spent nuclear fuel storage and therefore no non-radiological impacts from normal operations. Consequently, no cumulative impacts to air quality or water resources would result since the incremental addition of chemicals at the shipyard that might result from naval spent fuel activities would be very small. There are no current environmental problems associated with these materials.

The non-radiological cumulative transportation impacts for the population from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A. The non-radiological impacts associated with the transportation and storage of naval spent nuclear fuel for all of the alternatives considered would be low.

No cumulative land use impacts would be expected to occur as a result of spent nuclear fuel storage. The land that would be dedicated for this purpose is on existing federal property and situated in an industrial setting which has already been disturbed from its natural state (approximately 227 acres are developed land). The conversion of this space for storage of spent nuclear fuel would not result in the need to disturb undeveloped land or for additional land to be added to the federally owned property in the foreseeable future.

From a socioeconomic perspective, the introduction of naval spent nuclear fuel activities at the site would create a small number of additional jobs and could have a very small cumulative socioeconomic impact. The site currently employs approximately 4900 civilian personnel. No shipyard employment has been associated with spent nuclear fuel activities in the past since spent nuclear fuel activities have not been conducted at the site. An average of approximately 1 to 35 additional jobs might be added as a result of possible spent nuclear fuel activities in the future. The peak number of additional jobs created at the site in any given year would be approximately 89, which is associated with construction and operation of a water pool facility for storage of spent nuclear fuel. Considering that the regional labor force consists of approximately 121,550 workers, the additional number of added jobs under any alternative would have little or no discernible socioeconomic impact. These jobs would be filled either from within the existing site work force or from the available regional labor force without discernible effect. There are no foreseeable future projects planned at the site and no known projects planned in the region that would cause the small number of workers involved in naval spent nuclear fuel activities to become an important impact.

The cumulative impacts associated with non-radiological waste management are likewise expected to be small. As stated previously, any industrial wastes generated from naval spent nuclear fuel storage would be small and limited to industrial cleaning agents of the type normally encountered at the site. The volume of municipal solid wastes and sanitary wastes which would be generated is expected to be proportional to the number of additional workers added, and this small incremental increase would not be discernible. The amount of additional non-radiological wastes generated would not introduce any changes to the site's waste management practices and would not impose any additional stress on the capacity of on-site or off-site waste disposal or treatment facilities. Therefore, any cumulative impacts associated with the generation and disposal of additional wastes would be very small. There are no current environmental problems associated with these types of waste.

5.1.3.17 Unavoidable Adverse Effects

There are no discernible unavoidable adverse effects associated with the implementation of any of the alternatives and none which would help to choose among the alternatives. The alternative in which naval spent nuclear fuel is stored at the Portsmouth Naval Shipyard would cause the public to be exposed to small amounts of radiation, described in Section 5.1.3.12, and would result in less than one health effect in the entire population surrounding the shipyard. Similarly, continued operation of the storage facility would produce limited amounts of solid municipal waste and solid low-level radioactive waste. These amounts of waste would not produce any major impacts in the vicinity of the shipyard. There will be no changes to the ecological, cultural, geological, and aesthetic resources due to the implementation of any of the alternatives. There will also be no impact on ambient noise levels.

5.1.3.18 Irreversible and Irretrievable Commitments of Resources

The only irreversible and irretrievable commitment of resources that results from the alternative in which naval spent nuclear fuel would be stored at the Portsmouth Naval Shipyard would be the money which would be spent by the federal government to construct the necessary facilities. The total cost of storing spent naval nuclear fuel at the shipyards and prototype ranges from approximately $1.5 billion to $5.7 billion. This cost represents the total cumulative cost over the 40-year period for all of the shipyards and prototype. This cost includes construction costs of the new storage facilities, and, depending on the alternative selected, the operation of a limited examination facility at Puget Sound Naval Shipyard combined with the costs associated with shutting down ECF, or the operational costs of the INEL-ECF. The major expense in the highest cost alternatives is the procurement of shipping containers. Refer to Section 3.7 for a comparison of the total cumulative costs among alternatives.

5.1.4 PEARL HARBOR NAVAL SHIPYARD: PEARL HARBOR, HAWAII

5.1.4.1 Overview of Environmental Impacts

The following sections discuss the major differences in potential environmental consequences associated with the choice of alternatives that include storage of naval spent nuclear fuel at Pearl Harbor Naval Shipyard (hereafter referred to as Pearl Harbor). The environmental consequences associated with storage of naval spent nuclear fuel at Pearl Harbor are based on the estimates of naval spent nuclear fuel that will be stored at Pearl Harbor through the year 2035 and the current knowledge of the design features associated with spent fuel storage systems. The review of the environmental consequences associated with these alternatives has shown that the impact on the environment at Pearl Harbor associated with all activities is very small. There would be no impact to the environment in the vicinity of Pearl Harbor associated with any alternatives that do not involve Pearl Harbor.

5.1.4.2 Land Use

Construction of a storage area at Pearl Harbor for temporary naval spent nuclear fuel storage would require a modest change in the current land in use by the shipyard. A description of the alternate storage containers and water pools and their approximate storage locations is provided in Attachment D. Attachment C provides a comparison of naval spent nuclear fuel storage in water pools versus dry container storage. The area is already an industrial site; therefore, there will be no impact on land use.

The alternative of storing naval spent nuclear fuel in water pools would require that a water pool facility be constructed in the vicinity of the area that is designated for dry container storage. The water pool would have sufficient capacity to accommodate storage of all naval spent nuclear fuel expected to be stored at the shipyard.

No additional land use outside the shipyard would be required.

Native Hawaiian rights and interests would not be modified by construction or operations associated with any of the alternatives considered.

5.1.4.3 Socioeconomics

The calculated number of direct construction and operating jobs that would be required for the 10-year period between 1995 and 2004 for each storage alternative at the shipyard is provided in

Table 5.1.4-1. Since there would be no naval spent nuclear fuel storage or inspection activities at the shipyard under the 1992/1993 Planning Basis and Centralization alternatives, no additional jobs would be required at the shipyard under these alternatives.

Table 5.1.4-1. Number of construction and operating jobs created at Pearl Harbor Naval Shipyard for each alternative.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Railcar(1)	1	1	6	1	1	1	1	1	1	1
Immobile Containers on Pads(2)	1	1	1	1	2	6(3)	4	4	4	4
Shipping Containers on Pads (2)	1	1	1	1	2	6(3)	1	1	1	1
Water Pools(2)	16	16	46	71	88	62	77	35	35	35

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(1) Storage mode under the No Action and Decentralization alternatives.
(2) Storage mode under the Decentralization alternative.
(3) The construction jobs would last less than one year.

The only discernible socioeconomic consequence from the alternative of storing naval spent nuclear fuel at Pearl Harbor is that a relatively small number of construction workers (ranging from a few to a maximum of several hundred would be required for construction of the storage area). The work force would consist of skilled craftsmen and unskilled laborers. This work force would be needed during the storage facility construction and would be provided from within the area.

The operation of the naval spent nuclear fuel storage area using dry storage containers would require additional workers to secure the fuel in the storage area and to support surveillance and monitoring activities. For the alternative involving storing fuel in immobile dry storage containers, about 20 workers would be required to handle the naval spent nuclear fuel when it is placed into the storage containers. This work force would normally only be needed when fuel is being inserted into the containers. For the alternative involving shipping containers, fewer workers would be needed to handle and secure the containers in the storage area. The operation of a water pool facility for the alternative involving storing naval spent nuclear fuel in a water pool would require approximately 40 additional workers. The number required for any of the shipyard and prototype site storage alternatives would be small and would be expected to be supplied from either within the existing shipyard work force or the local work force. Considering that the Department of Defense employs approximately 10,900 civilians at the Pearl Harbor naval base, the addition of workers to support the alternatives would have no discernible impact on the local socioeconomic conditions of the Pearl Harbor site.

For the alternatives where dry storage containers would be manufactured, some additional jobs would be created in the locations where the containers are made. The process of selecting the container manufacturer is subject to federal procurement requirements and would be initiated after the Record of Decision. Consequently, the specific socioeconomic impacts from container fabrication cannot be specified. The net effect of container fabrication would be to create additional jobs and bolster the local economy of the area(s) where containers are made. It is considered unlikely that the selection of the contractor would depend on the alternative storage site selected, so the jobs associated with construction of casks provide no basis for selection of a storage site.

5.1.4.4 Cultural Resources

The action considered will not affect any site that is listed on the National Register of Historic Places (NPS 1991), any known archaeological areas, or any other cultural resources. Therefore, there would be no impacts to cultural resources associated with the alternative of storing naval spent nuclear fuel at this location.

None of the alternatives considered would impact known archaeological or Native Hawaiian sites. Procedures which comply with all applicable laws and regulations would be implemented to protect previously undetected archaeological and cultural sites.

5.1.4.5 Aesthetic and Scenic Resources

The naval spent nuclear fuel storage area would be located within the Pearl Harbor site which is an existing industrial setting and would not affect the visual quality of the area since it is compatible with the landscape character of the site. Physical changes to the Pearl Harbor site resulting from storage area construction will not alter this setting. There are no particulate air emissions associated with storage of naval spent nuclear fuel and thus no visibility impacts are expected. No aesthetic or scenic resources in the vicinity of the shipyard would be affected by the construction and operation of the storage facility.

5.1.4.6 Geology

The construction and operation of the naval spent nuclear fuel storage facility at Pearl Harbor is not expected to affect the geologic character or resources of the region. If an alternative were selected which required a storage area to be constructed, the ground surface would be excavated as necessary to prepare the surface. This would not affect the geological characteristics of the underlying layers nor the characteristics of the Koolou and Wainae aquifers or vadose zone. For the alternative of storing fuel in a water pool facility, the ground surface would need to be excavated to a depth of approximately 40 feet. This excavation would not affect the geological characteristics of the area.

5.1.4.7 Air Resources

5.1.4.7.1 Radiological Consequences.

No airborne radionuclide releases from normal operations are expected to occur as a result of naval spent nuclear fuel being stored in dry storage containers. The fuel would be contained such that at least two barriers exist to prevent fission products from becoming airborne. These barriers would retain the naval spent nuclear fuel in an air-tight containment until it is moved to a permanent storage site and there would be no airborne radioactive material released from routine operations for this method of storage. The only radiation exposure would be direct radiation from the array of filled storage containers. The filled storage containers would be fenced off and shielded if necessary such that there would be no distinguishable effect on normal background radiation levels at the site perimeter.

For the alternative where naval spent nuclear fuel would be stored in a water pool, airborne radionuclide releases are expected to be less than the emissions from the Idaho National Engineering Laboratory (INEL) Expended Core Facility (ECF) because the water pool size would be smaller, no naval spent nuclear fuel inspection operations beyond visual examinations would be conducted, and no shielded cell operations would be conducted at Pearl Harbor. To conservatively estimate the radiological consequences, airborne releases based on ECF releases from 1991 are used. The radiological source term used and the detailed calculations performed to determine expected normal releases are provided in Attachment F.

The radiation exposures to human beings due to estimated radionuclide releases to the atmosphere plus direct radiation from the stored naval spent nuclear fuel at the shipyards for both the alternative involving water pool storage and the alternative involving dry storage were calculated as described in Attachment F.

A person on the shipyard boundary at the location where the largest exposures would be received was used as the hypothetical maximally exposed off-site individual (MOI) for postulated releases of radioactive material from the stored naval spent nuclear fuel. The population data used to calculate population exposures were taken from 1990 census data provided by the U.S. Census Bureau. Meteorology data were obtained as described in Attachment F. Estimated exposures to workers were also calculated.

The hypothetical exposures calculated are based on an exposure to the estimated average effluents and the direct radiation exposure for one year from the naval spent nuclear fuel stored at the shipyard. The calculations include the external effective equivalent exposure from the ground deposition, deposition to surface water, and air immersion pathways and the 50-year committed effective equivalent exposure from internal exposure through the ingestion and inhalation pathways. All pathways were considered for persons potentially exposed, except that the ingestion pathway was omitted for the workers because they do not grow their food on-site. Solubilities which would produce the highest calculated exposures were chosen for internal exposure factors. Values for human dietary consumption patterns were taken from "Age Dependent Values of Dietary Intake for Assessing Human Exposures to Environmental Pollutants" (Rupp 1980). The hypothetical exposures calculated can be converted into a risk of fatal cancer or a risk of non-fatal health detriments (e.g., non-fatal cancers, hereditary defects) based on recommendations of the International Commission on Radiological Protection (ICRP 1991).

Attachment F summarizes the calculated exposures and fatal cancers to the worker, the maximally exposed off-site individual (MOI), nearest public access (NPA), and the population from releases of radioactivity and direct radiation exposure in one year for each location and storage mode. Section 3.7 provides a comparison of the annual number of fatal cancers calculated for the general population for each location and alternative.

The number of fatal cancers calculated is so small that there would be essentially no fatal cancers resulting from the storage of naval spent nuclear fuel during the time it could reasonably be expected to continue to be stored. Putting this into perspective, it could be stated that one member of the population might experience a fatal cancer due to incident-free storage of naval spent nuclear fuel at Pearl Harbor if operations continued for 14,300 years.

5.1.4.7.2 Non-radiological Consequences.

As noted in Attachment F, no increase in non-radioactive airborne emissions would be expected to result from naval spent nuclear fuel storage facility operations. Storage facility operations would not involve use of carcinogenic toxins, criteria pollutants, or other hazardous or toxic chemicals except that small quantities of industrial cleaning agents and paint thinner may be used for housekeeping and cleanliness control and these would be the same as those already used at the shipyard. Consequently, there would be no impact on ambient air quality as a result of implementing any of the alternatives at the shipyard.

If an alternative were to be selected that required a storage facility to be constructed or renovated, fugitive dust emissions would be expected to result from excavation operations. The quantity of dust generated would be small, consistent with typical excavation activities, and controlled within local requirements for dust control.

5.1.4.8 Water Resources

5.1.4.8.1 Radiological Consequences.

Naval spent nuclear fuel storage operations at Pearl Harbor would not result in discharges of radioactivity in liquid effluents during routine operation regardless of the alternative selected for storage of naval spent nuclear fuel. The health effect due to fallout of nuclides released to the air onto the surface water is included in the analysis results discussed in Section 5.1.4.7. The air fallout impact is so small that there would be no distinguishable radiation levels in the water.

Based on FIRM and topographical maps of areas approximately three miles away, the location considered for the interim storage of naval spent nuclear fuel is in the 100-year floodplain. However, the location considered for naval spent nuclear fuel is not in a high-hazard area (as defined by Title 10, Part 1022 of The Code of Federal Regulations for floodplains) which is an area where frequent flooding occurs. Since the majority of the shipyard is already developed and covered with impervious material, construction and operation of a naval spent nuclear fuel storage facility at the shipyard would produce no discernible impacts on the floodplain.

Flooding in the area where shipping and immobile dry storage containers are stored would not result in any adverse environmental consequences. These containers are completely sealed such that no radioactivity would be released from the interior even if they were completely submerged. In addition, the massive nature of these containers prevents them from floating or moving during a flood.

Since the shipyard resides in close proximity to a floodplain, the design of the facility and equipment would minimize the potential for flooding and damage to the facility. However, in the event a water pool facility would be flooded, the exchange of pool water with the flood waters could occur. As discussed in Attachment F, Section F.1.4.2.1.6.2, the radioactivity concentration in the ECF water pool is below the Nuclear Regulatory Commission limits specified in Title 10, Part 20 of The Code of Federal Regulations for liquid effluent except for Co-60 which is slightly higher (water pools used for storage or examination of naval spent nuclear fuel would be maintained to comparable concentrations). Any release of radioactivity would have to result from the exchange of floodwater with the pool water. This exchange would reduce the level of radioactivity even further. Consequently, no adverse environmental impacts would result from flooding of water pools at naval spent nuclear fuel storage sites.

5.1.4.8.2 Non-radiological Consequences.

Other than chemicals used to maintain the storage area, no hazardous wastes would be generated by the storage of naval spent nuclear fuel at Pearl Harbor. Any hazardous liquid effluents that may be generated at the storage area would be disposed of at an Environmental Protection Agency approved disposal site.

The only source for liquid discharges from the naval spent nuclear fuel storage operations to the environment consists of storm water runoff which would be consistent with the type of discharges associated with common light industrial facilities and related activities. It can be concluded that there would be no impact to the human environment due to runoff water from the naval spent nuclear fuel storage area.

The increased water usage under any of the alternatives would be negligible compared to the existing shipyard demand.

5.1.4.9 Ecological Resources

There are no threatened or endangered species known to exist within the Pearl Harbor shipyard and no major changes to the industrial environment are planned. Therefore, no major ecological impacts to the region would result from selection of any of the alternatives.

The conceptual location where naval spent nuclear fuel would be stored is illustrated in Attachment D. This location is within an existing industrial complex and is surrounded by buildings and paved areas. The industrial nature of the shipyard and the fact that the land has already been disturbed from its natural state by earlier activities mean that plant or animal species sensitive to disturbance by human activities would not be expected to be present. Therefore, there would be no ecological impacts associated with construction or operation of a spent nuclear fuel storage area at this location. The radiological controls that are in effect at the shipyard ensure that the radiation levels in the vicinity of the shipyard are maintained at or near natural background. Since these same controls would be applied to spent nuclear fuel activities, no ecological effects due to radioactive material would be expected to occur.

5.1.4.10 Noise

Pearl Harbor is an existing industrial-type environment characterized by noise from truck and automobile traffic; ship loading cranes and related diesel-powered equipment; and continuously operating transmission lines for steam, fuel, water, and related pumping systems for those and other liquids. No ambient noise level increases are expected to occur as a result of any of the alternatives. Therefore, no noise impacts would be expected to occur.

5.1.4.11 Traffic and Transportation

Shipments of radioactive materials in the Naval Nuclear Propulsion Program are required to be made in accordance with applicable regulations of the U. S. Department of Transportation, U.S. Department of Energy, and the U.S. Nuclear Regulatory Commission. The purpose of these regulations is to ensure that shipments of radioactive material are adequately controlled to protect the environment and the health and safety of the general public. These regulations are applicable to all radioactive material shipments and provide requirements for the container design, certification, and identification as applicable for the specific quantity, type, and form of radioactive material being shipped. Naval shipping container design requirements invoke shielding and integrity specifications and meet all regulatory requirements. They provide for testing of container designs, training and qualification of workers who construct containers, and quality control inspections during fabrication to ensure that the containers will meet their design requirements. A detailed description of the shipping containers used for naval spent nuclear fuel shipments is provided in Attachment A. A description of the impacts from normal and accident conditions associated with transportation of naval spent nuclear fuel is provided in Attachment A.

5.1.4.11.1 Regional Infrastructure.

The alternatives under consideration are described in Section 3. The No Action alternative or the first variation of the Decentralization alternative would store the naval spent nuclear fuel on-site. This alternative would reduce the number of rail shipments from the shipyard or prototype site compared to the past practice of transporting all naval spent nuclear fuel to INEL. The second variation of the Decentralization alternative would ship about 10 percent of the naval spent nuclear fuel to Puget Sound. This would have some transportation impact, but not as much as transporting all naval spent nuclear fuel off-site. The third Decentralization alternative ships all naval spent nuclear fuel to INEL, examines it, and returns it to the original shipyard or prototype site. This alternative involves more transportation than the previous practice of transporting naval spent nuclear fuel to INEL, since the naval spent nuclear fuel is not returned from INEL to the original site. The 1992/1993 Planning Basis alternative, the Regionalization at INEL alternative, or the Centralization at INEL alternative would involve the same transportation as has been required in the past, namely transportation to INEL and retention there. The Centralization alternative at the Hanford Site would result in more transportation impact than any of the previous alternatives, due to the distances and population distribution between Hanford and the shipyards and prototypes. The Centralization alternative at the Savannah River Site would result in the most transportation impact of naval spent nuclear fuel of any of the alternatives.

5.1.4.11.2 Site Infrastructure.

The alternative associated with naval spent nuclear fuel storage at Pearl Harbor would not affect local highway traffic because any increase in the work force would represent a very small incremental increase in overall traffic to and from the shipyard. There would be no change in the internal traffic in the shipyard because naval spent nuclear fuel is held temporarily even when it is transported off-site.

5.1.4.12 Occupational and Public Health and Safety

Detailed analyses of incident-free naval spent nuclear fuel transportation and storage and handling impacts on worker and public health are described in Attachment A (transportation) and Attachment F (storage and inspection). The transportation analysis results, and the storage and handling analysis are summarized separately in the following subsections.

5.1.4.12.1 Incident-free Transportation Occupational and Public Health and Safety.

The radiological and non-radiological health effects associated with the incident-free transportation of naval spent nuclear fuel and test specimens have been assessed for the general population, transportation workers, and hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancers as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. The details of the transportation analysis are provided in Attachment A.

5.1.4.12.2 Incident-free Occupational and Public Health and Safety During Naval Spent

Nuclear Fuel Storage and Handling. The public health and safety impacts of radioactivity releases and direct radiation from storage of naval spent nuclear fuel were analyzed as discussed in Section 5.1.4.7 and Attachment F. Attachment F summarizes the results of the analysis of radioactivity releases and direct radiation from stored naval spent nuclear fuel. This analysis shows that the exposure to the worker, maximally exposed off-site individual, and nearest public access from stored naval spent nuclear fuel would result in far less than one fatality per year. For perspective, it could be stated that one member of these population groups might experience a fatal cancer due to storage of naval spent nuclear fuel at Pearl Harbor if operations continued for 14,300 years.

Projections of the number of occupational accidents that might occur during construction and operation of naval spent nuclear fuel storage and examination facilities have been made for each alternative. These projections are presented in Attachment F. Based on the results of these projections, it is concluded that the number of occupational fatalities and injuries or illnesses for construction activities and storage and examination operations would be very small for any alternative.

No public or occupational radiological health and safety impacts would be expected to result from naval spent nuclear fuel storage area construction activities since the construction would not involve radioactive work.

Attachment F also discusses toxic chemical issues for naval spent nuclear fuel handling and storage. Attachment F concludes that there would be no additional types or volumes of chemicals required at the shipyards or prototype site for naval spent nuclear fuel storage. Therefore, there is no incident-free non-radiological impact resulting from storage of naval spent nuclear fuel at the shipyards or prototype site.

5.1.4.12.3 Incident-free Occupational and Public Health and Safety Effects on Environmental Justice Due to Naval Spent Nuclear Fuel Storage and Handling.

As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from normal operations associated with the management of naval spent nuclear fuel at the Pearl Harbor Naval Shipyard would be small under any of the alternatives considered. For example, it is unlikely that a single fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to normal operations or accident conditions for any of the alternatives considered present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is true for normal operations because the effects of routine operations are so small. It is also true for accident conditions because the consequences of any accident would depend on the random conditions at the time it occurred. The wind directions at Pearl Harbor are variable, but the wind direction which occurs most frequently is toward the southwest, away from land and residential areas. Similarly, the conclusion is not affected by concerns related to subsistence consumption of fish or game since environmental monitoring in the vicinity of this relatively small and restricted site has shown no detectable difference in the amounts of radioactivity present in the environment from levels in similar parts of the region.

To place the impacts on environmental justice in perspective, the risk associated with routine naval spent nuclear fuel management operations under any of the alternatives considered would be less than one fatality per year for the entire population. For comparison, in 1990 there were approximately 510,000 cancer deaths in the United States population and there were about 64,000 cancer deaths among people of color in the U. S. Even if all of the impacts associated with one of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would be unlikely to experience a single additional cancer fatality in any year. Therefore, the cancer risk for that population from naval spent nuclear fuel management would not constitute a disproportionately high and adverse impact on human health or the environment. The same conclusion can be drawn for low-income groups.

5.1.4.13 Utilities and Energy

If an alternative associated with the storage of naval spent nuclear fuel at Pearl Harbor were to be selected, construction and operation of the storage area would not be expected to require a large expenditure of utilities and energy resources. Construction activities would require quantities of water and electricity typical of any small to medium size construction project. Operation of the storage facility would likely require only small amounts of electricity for lighting and to support industrial equipment necessary to move spent nuclear fuel (e.g., cranes). Alternatives associated with water pool storage would require heating, ventilation, water, and electrical systems suitable for a work environment and to properly filter and exhaust the airborne discharges to the atmosphere. The utility and energy demands would be less than those required to operate ECF (10,000 MWh per year) (Section 5.2.13) since the water pool used for spent fuel storage would be smaller and no spent fuel operations beyond visual examinations would be conducted in the water pool.

The amount of utilities and energy expected to be consumed would be a small incremental increase in the total amount of utilities and energy used at the shipyard and would not result in any discernible environmental consequence.

5.1.4.14 Facility and Transportation Accidents

5.1.4.14.1 Facility Accidents. There has never been an accident in the history of the Naval

Nuclear Propulsion Program that resulted in a significant release of radioactivity to the environment or that resulted in radiation exposure to workers in excess of abnormal occurrence limits on exposures as defined by the U.S. Nuclear Regulatory Commission. A description of potential accidents considered and a summary of the accident analyses that were conducted with regards to the storage of naval spent nuclear fuel is contained in Attachment F.

5.1.4.14.1.1 Radiological Accidents. Section 3.7.3 provides a summary of the impacts

due to the most severe accidents considered for each site. The facility accident with the greatest potential impact at Pearl Harbor involves an airplane crash. An accident of this magnitude would result in a calculated 26 fatal cancers to the general population over 50 years, as described in Attachment F. The likelihood of such an accident occurring is 1 x 10-5, which is very small. For perspective, an accident such as this would not be expected to occur unless the facility operated for about 100,000 years.

5.1.4.14.1.2 Non-radiological Accidents. As discussed in detail in Attachment F, the

limiting hypothetical non-radiological accident for naval spent nuclear fuel storage in a water pool at a shipyard or prototype location would be a diesel fuel spill and fire. A catastrophic failure of a diesel fuel storage tank that might be used for an emergency diesel generator to provide backup electrical power was postulated to occur, resulting in the spilling of the entire quantity of diesel fuel with a subsequent fire. The fire would generate the following toxic chemicals:

- Carbon monoxide
- Oxides of nitrogen (90% nitric oxide and 10% nitrogen dioxide)
- Lead
- Sulfur dioxide.

Measures would be taken to reduce the health impacts of potential releases of toxic materials. These measures would involve controls to protect both workers and the general public. The naval shipyard and prototype sites have emergency planning, emergency preparedness, and emergency response programs in place to protect both workers and the public, and involve established resources such as warning communications, fire departments, and emergency command centers.

The airborne concentrations of the combustion products listed above, resulting from the fire, were calculated at the locations of the on-site individuals, an individual at the site boundary, and the general population within a 50-mile radius of the facility. Detailed results are presented in Attachment F. If the accidental fire that has been hypothesized were to actually occur, the safety measures that would be in place would ensure no adverse health impacts to the general public and minimal health impacts to the workers.

5.1.4.14.2 Transportation Accidents.

Shipments of radioactive materials associated with naval spent nuclear fuel have never resulted in any measurable release of radioactivity to the environment (NNPP 1994a). There have never been any significant accidents involving release of radioactive material during shipment since the Naval Nuclear Propulsion Program began. The effects of potential transportation accidents during the various stages of transportation of naval spent nuclear fuel are presented in Attachment A.

The health effects associated with accidents during shipments of naval spent nuclear fuel and test specimens have been assessed for the general population and the hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancers as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. The details of the transportation analysis are provided in Attachment A.

5.1.4.14.3 Other Impacts of Accidents.

In addition to the possible human health effects associated with facility or transportation accidents described in the preceding sections, other effects such as the impacts on socioeconomics and land use in the area and the costs of cleanup have been estimated in order to develop a perspective and to evaluate potential differences among alternatives. The analyses described in Attachment F showed that an area ranging from about 8 acres extending approximately a quarter mile (for an inadvertent criticality accident) to about 110 acres extending approximately 0.9 mile (for a large airplane crashing into a dry storage container) might be contaminated to the point where exposure could exceed 100 millirem per year. Beyond these distances, the exposure would be less than 100 millirem per year, the Nuclear Regulatory Commission's standard for protection of the general population from radiation. Persons who live in this area might be evacuated or otherwise experience restrictions in their daily activities for a brief period, and those who work at locations within this area might be prevented from going to their jobs until measures had been taken to reduce the potential for exposure. It should be noted that all of the affected area within about three-quarters of a mile from the spent nuclear fuel facility would be within the boundaries of the federally owned site.

An accident might result in short-term restrictions on access to a relatively small area, but there would be no enduring impacts on cultural or similar resources or concerns such as Native Hawaiian rights or interests, partially because the area involved would be small and partly because all remedial actions would be conducted in a careful, controlled manner in full compliance with applicable laws and regulations. The area impacted would vary only slightly among the alternatives considered. Overall, the risks are small so these considerations do not assist in distinguishing among alternatives.

Facility or transportation accidents associated with any of the alternatives would not have an appreciable effect on the ecology of the area, considering the potential for human health effects and the amount of land which might be affected, as described in earlier parts of this section. There is little consensus among scientists on methods for estimating the effects of radiation on ecological resources such as plant or animal life, but since human health effects for all the accidents analyzed are small and most plants and animals are not thought to be more sensitive to radiation than human beings, the small impacts on human health provide an indication that the impacts on animal and plant species in the area would also be small for all alternatives considered. Similarly, since the areas which might be contaminated to measurable levels by chemicals or radioactive material during the hypothetical accidents would be relatively small, any effects on the ecology would be limited to small areas. There are no endangered or threatened species unique to the area surrounding the federally owned site, so an accident would not be expected to result in destruction of any species for any of the alternatives considered. The effects of accidents related to any of the alternatives and any associated cleanup which might be performed would be localized in a small area extending only a short distance beyond the boundaries of the federally owned site and thus would not be expected to appreciably affect the potential for survival of any endangered or threatened species which might occupy wetlands or other habitat in the area. Based on these considerations, evaluation of impacts of accidents on ecological resources does not help to distinguish among alternatives.

5.1.4.14.4 Effects of Accidents on Environmental Justice Due to Naval Spent Nuclear

Fuel Storage and Handling.
As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from facility or transportation accidents associated with the management of naval spent nuclear fuel at the Pearl Harbor Naval Shipyard would be small under any of the alternatives considered. For example, it is unlikely that a single additional fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to an accident for any of the alternatives considered would present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects from accidents associated with the management of naval spent nuclear fuel would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is because the consequences of any accident would depend on the random conditions in effect at the time an accident occurred. The wind directions at Pearl Harbor are variable, but the wind direction which occurs most frequently is toward the southwest, away from land and residential areas.

To place the impacts on environmental justice in perspective, the risk associated with accidents caused by naval spent nuclear fuel management under any of the alternatives considered would amount to less than one additional fatality per year in the entire population. For comparison, in 1990 there were approximately 40,000 traffic fatalities in the United States population and there were about 7,400 deaths caused by traffic accidents among people of color in the U. S. Even if all of the additional cancer deaths associated with an accident involving any of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would experience less than one additional fatal cancer per year. The same conclusion can be drawn for low-income groups.

5.1.4.15 Waste Management

The alternative in which naval spent nuclear fuel is stored at Pearl Harbor would produce limited amounts of solid municipal waste, solid low-level radioactive wastes, and hazardous wastes.
In addition, no transuranic or high-level radioactive wastes would be generated by spent nuclear fuel activities at the site under any alternative. The quantity of industrial wastes generated would be small and most likely consist of industrial cleaning agents of the type normally encountered at the site.
Small quantities of sanitary wastes would result from the additional work force but this volume would be small. The wastes produced from the storage of naval spent nuclear fuel would be controlled and minimized in accordance with the existing waste management programs at Pearl Harbor. The amount of additional wastes generated would be minimal compared to the existing baseline and would not cause any adverse impacts to public health and safety and the environment in the vicinity of Pearl Harbor.

5.1.4.16 Cumulative Impacts

5.1.4.16.1 Radiological Cumulative Impacts. Spent nuclear fuel storage at the site would not result in discharges of radioactivity in liquid effluents during routine operations regardless of the alternative selected. Therefore, there would be no incremental addition of radioactivity to surface or ground water as a result of normal operations for any alternative. For alternatives involving the storage of spent nuclear fuel in dry storage and shipping containers, no airborne radioactivity emissions are expected, so there would be no cumulative air quality impacts associated with these storage methods. Consequently, the only radiological cumulative impacts that would result from dry storage alternatives would be due to direct radiation exposure from the stored containers of spent nuclear fuel.

For alternatives involving the storage of naval spent nuclear fuel in water pools, there would be no discernible direct radiation exposure to the public from the fuel elements due to the shielding provided by the water in the pool. Therefore, any cumulative impacts which would result from water pool storage would be primarily due to airborne emissions, and the addition of these emissions would cause an indiscernible change in the emissions in the area (see Section 5.1.4.7). Current operations at the site are in compliance with Title 40, Code of Federal Regulations, Part 61, "National Emission Standards for Hazardous Air Pollutants." Cumulative air emissions would not threaten to exceed any applicable air quality requirement or regulation, either federal, state, or local in radiological and non-radiological categories.

A summary of the cumulative radiological impacts is provided in the following section.

An overview of the historical radiological impacts from naval nuclear operations at Pearl Harbor and from transportation of naval spent nuclear fuel is provided in Section 4.1.4.12 and detailed analyses are provided in Attachments F and A. Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

The radiological impacts associated with the alternative where naval spent nuclear fuel would be stored at Pearl Harbor are very small and are described in Section 5.1.4.12, with the detailed results of analyses provided in Attachment F. In order to calculate cumulative impacts for the period between 1995 and 2035, the annual radiological impacts associated with each location and alternative were summed over 40 years. The results of this summation are tabulated in Tables 3-5 and 3-6 of Section 3.

The cumulative transportation impacts for the population groups from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated and are very small. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A and summarized in Section 3.7.4.

The total exposure to the population in the vicinity of Pearl Harbor from all of the alternatives considered would be approximately 5.6 person-rem. This means that there would be much less than one fatal cancer from these operations over the entire 40-year period evaluated. The total exposure to a theoretical maximally exposed off-site individual living at the shipyard boundary for the entire 40-year period would be 8.0 x 10-4 rem due to the alternative resulting in the largest exposure. This maximally exposed off-site individual would have a 4.0 x 10-7 risk of contracting a fatal cancer during his or her lifetime due to storage of spent nuclear fuel. When existing site radiological impacts due to naval nuclear operations are added to the impacts of the most limiting spent nuclear fuel alternative, the exposure to the population would be 6.8 person-rem and to the maximally exposed off-site individual would be 9.2 x 10-4 rem. This still results in much less than one fatal cancer in the population and the risk of the maximally exposed off-site individual contracting a fatal cancer during his or her lifetime is 4.6 x 10-7.

The total exposure related to naval spent nuclear fuel activities to a worker assumed to be working continually 100 meters from the spent nuclear fuel under the alternative resulting in the largest exposure is 8.4 x 10-2 rem accumulated over 40 years. That corresponds to a fatal cancer risk of 3.4 x 10-5 during the worker's lifetime. The exposure to the same worker when existing site radiological impacts due to naval nuclear operations are added to the spent nuclear fuel exposure is essentially the same. The impacts associated with transportation of naval spent nuclear fuel for all of the alternatives considered would be similarly low.

No contribution to cumulative impacts from accidents involving naval spent nuclear fuel has been included in the analyses presented in this Environmental Impact Statement because there has never been a nuclear reactor accident, criticality accident, transportation accident, or any release of radioactivity which had a significant effect on the environment.

Sections 4.1.4.14 and 5.1.4.15 describe the management of low-level radioactive waste and mixed waste at the site. The volume of low-level radioactive wastes which would be generated under the alternatives has not been calculated. However, considering the nature of radiological work that would be associated with spent nuclear fuel storage activities, the amount of low-level radioactive waste produced during spent nuclear fuel activities would be much less than 20 percent of the current site generation rate (84 m3 per year). This additional radioactive waste would not introduce any changes to the site's waste management practices. The small amount of additional material involved would not impose any discernible additional stress on the capacity of the radioactive waste burial ground. Therefore, any cumulative impacts associated with the generation and disposal of additional low-level wastes would be very small.

Since no mixed, transuranic, or high-level radioactive wastes would be generated by spent nuclear fuel activities at this site under any alternative, there would be no cumulative impacts associated with these materials.

5.1.4.16.2 Non-radiological Cumulative Impacts.

An overview of the historical non-radiological impacts from naval nuclear operations at Pearl Harbor and from transportation of naval spent nuclear fuel is provided in Section 4.1.4.12 and detailed analyses are provided in Attachments F and A. Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no non-radiological cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

The non-radiological impacts associated with the alternative where naval spent nuclear fuel would be inspected or stored at Pearl Harbor are described in Section 5.1.4.12, with the detailed results of analyses provided in Attachment F. As summarized in Section 5.1.4.12, there would be no additional chemicals required at the shipyard for naval spent nuclear fuel storage and therefore no non-radiological impacts from normal operations. Consequently, no cumulative impacts to air quality or water resources would result since the incremental addition of chemicals at the shipyard that might result from naval spent fuel activities would be very small. There are no current environmental problems associated with these materials.

The non-radiological cumulative transportation impacts for the population from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A. The non-radiological impacts associated with the transportation and storage of naval spent nuclear fuel for all of the alternatives considered would be low.

No cumulative land use impacts would be expected to occur as a result of spent nuclear fuel storage. The land that would be dedicated for this purpose is on existing federal property and situated in an industrial setting which has already been disturbed from its natural state. The conversion of this space for storage of spent nuclear fuel would not result in the need to disturb undeveloped land or for additional land to be added to the federally owned property in the foreseeable future.

From a socioeconomic perspective, the introduction of naval spent nuclear fuel activities at the site would create a small number of additional jobs and could have a very small cumulative socioeconomic impact. The site currently employs approximately 5000 civilian personnel. No shipyard employment has been associated with spent nuclear fuel activities in the past since spent nuclear fuel activities have not been conducted at the site. An average of approximately 1 to 35 additional jobs might be added as a result of possible spent nuclear fuel activities in the future. The peak number of additional jobs created at the site in any given year would be approximately 88, which is associated with construction and operation of a water pool facility for storage of spent nuclear fuel. Considering that the regional labor force consists of approximately 407,530 workers, the additional number of added jobs under any alternative would have little or no discernible socioeconomic impact. These jobs would be filled either from within the existing site work force or from the available regional labor force without discernible effect. There are no foreseeable future projects planned at the site and no known projects planned in the region that would cause the small number of workers involved in naval spent nuclear fuel activities to become an important impact.

The cumulative impacts associated with non-radiological waste management are likewise expected to be small. As stated previously, any industrial wastes generated from naval spent nuclear fuel storage would be small and limited to industrial cleaning agents of the type normally encountered at the site. The volume of municipal solid wastes and sanitary wastes which would be generated is expected to be proportional to the number of additional workers added, and this small incremental increase would not be discernible. The amount of additional non-radiological wastes generated would not introduce any changes to the site's waste management practices and would not impose any additional stress on the capacity of on-site or off-site waste disposal or treatment facilities. Therefore, any cumulative impacts associated with the generation and disposal of additional wastes would be very small. There are no current environmental problems associated with these types of waste.

5.1.4.17 Unavoidable Adverse Effects

There are no discernible unavoidable adverse effects associated with the implementation of any of the alternatives and none which would help to choose among the alternatives. The alternative in which naval spent nuclear fuel is stored at Pearl Harbor would cause the public to be exposed to small amounts of radiation, described in Section 5.1.4.12, and would result in less than one health effect in the entire population surrounding the shipyard. Similarly, continued operation of the storage facility would produce limited amounts of solid municipal waste and solid low-level radioactive waste. These amounts of waste would not produce any major impacts in the vicinity of the shipyard. There will be no changes to the ecological, cultural, geological, and aesthetic resources due to the implementation of any of the alternatives. There would also be no expected impact on ambient noise levels.

5.1.4.18 Irreversible and Irretrievable Commitments of Resources

The only irreversible and irretrievable commitment of resources that results from the alternative in which naval spent nuclear fuel would be stored at Pearl Harbor would be the money which would be spent by the federal government to construct the necessary facilities. The total cost of storing spent naval nuclear fuel at the shipyards and prototype ranges from approximately $1.5 billion to $5.7 billion. This cost represents the total cumulative cost over the 40-year period for all of the shipyards and prototype. This cost includes construction costs of the new storage facilities, and, depending on the alternative selected, the operation of a limited examination facility at Puget Sound Naval Shipyard combined with the costs associated with shutting down ECF, or the operational costs of the INEL-ECF. The major expense in the highest cost alternatives is the procurement of shipping containers. Refer to Section 3.7 for a comparison of the total cumulative costs among alternatives.

5.1.5 KENNETH A. KESSELRING SITE: WEST MILTON, NEW YORK

5.1.5.1 Overview of Environmental Impacts

The following sections discuss the major differences in potential environmental consequences associated with the choice of the alternatives that include storage of naval spent nuclear fuel at the Kenneth A. Kesselring Site. The environmental consequences associated with the storage of naval spent nuclear fuel at the Kesselring Site are based on the estimates of naval spent nuclear fuel that would be stored at the Kesselring Site through the year 2035 and current knowledge of the design features associated with spent fuel storage systems. The review of the environmental consequences associated with these alternatives has shown that the impact on the environment at the Kesselring Site associated with these activities is very small. There would be no impact to the environment in the vicinity of the Kesselring Site associated with any alternatives that do not involve the Kesselring Site.

5.1.5.2 Land Use

Construction of a storage area at the Kesselring Site for temporary storage of naval spent nuclear fuel would require little rearrangement of existing on-site facilities. The area is already an industrial site; therefore, there would be no impact on land use. A description of the alternate storage containers and water pools and their approximate locations is provided in Attachment D. Attachment C provides a comparison of naval spent nuclear fuel storage in water pools versus dry container storage.

No additional land within or outside the Kesselring Site would be required for fuel storage.

Native American rights and interests would not be modified by construction or operations associated with any of the alternatives considered.

5.1.5.3 Socioeconomics

The calculated number of direct construction and operating jobs that would be required for the 10-year period between 1995 and 2004 for each storage alternative at the Kesselring Site is provided in Table 5.1.5-1. Since there would be no naval spent nuclear fuel storage or inspection activities at the Site under the 1992/1993 Planning Basis and Centralization alternatives, no additional jobs would be required at the Site under these alternatives.

Table 5.1.5-1. Number of construction and operating jobs created at the Kesselring Site for each alternative.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Railcar(1)	1	1	6	1	1	1	1	1	1	1
Immobile Containers on Pads(2)	1	1	1	1	2	6(3)	3	3	3	3
Shipping										

Containers on Pads (2)	1	1	1	1	2	6(3)	1	1	1	1
Water Pools(2)	16	16	43	66	81	58	62	24	24	24

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(1) Storage mode under the No Action and Decentralization alternatives.
(2) Storage mode under the Decentralization alternative.
(3) The construction jobs would last less than one year.

The only discernible socioeconomic consequence from the alternative of storing naval spent nuclear fuel at the Kesselring Site is that a relatively small number of construction workers (ranging from a few to a maximum of several hundred would be required for construction of the storage area). The work force would consist of skilled craftsmen and unskilled laborers. This work force would be needed during the storage facility construction and would be available from within the area.

The operation of the naval spent nuclear fuel storage area using dry storage containers would require additional workers. Personnel are required to secure fuel in the storage area and to support surveillance and monitoring activities associated with naval spent nuclear fuel storage operations. For the alternative involving storing fuel in immobile dry storage containers, about 20 workers would be required to handle the spent nuclear fuel when it is placed into the storage containers. This work force would normally only be needed when fuel is being inserted into the containers. For the alternative involving shipping containers, fewer workers would be needed to handle and secure the containers in the storage area. If the alternative of storing naval spent nuclear fuel in water pools were selected, approximately 20 workers would be required. These workers would be expected to be supplied from either within the existing Kesselring Site work force or from the local work force. Considering that the Kesselring Site employs approximately 1450 workers, the addition of workers to support the alternatives would have no discernible impact on the local socioeconomic conditions of the Kesselring Site.

For the alternatives where dry storage containers would be manufactured, some additional jobs would be created in the locations where the containers are made. The process of selecting the container manufacturer is subject to federal procurement requirements and would be initiated after the Record of Decision. Consequently, the specific socioeconomic impacts from container fabrication cannot be specified. The net effect of container fabrication would be to create additional jobs and bolster the local economy of the area(s) where containers are made. It is considered unlikely that the selection of the contractor would depend on the alternative storage site selected, so the jobs associated with construction of casks provide no basis for selection of a storage site.

5.1.5.4 Cultural Resources

No site that is listed on the National Register of Historic Places (NPS 1991), any known archaeological areas, or any other cultural resources would be affected by the storage of naval spent nuclear fuel at the Kesselring Site. Therefore, there would be no impact to cultural resources from the alternative of storing naval spent nuclear fuel at the Kesselring Site.

None of the alternatives considered would impact known archaeological or Native American sites. Procedures which comply with all applicable laws and regulations would be implemented to protect previously undetected archaeological and cultural sites.

5.1.5.5 Aesthetic and Scenic Resources

The naval spent nuclear fuel storage area would be located in an existing area within the security perimeter of the Kesselring Site which is an existing light industrial setting. There would be minor changes to the Site resulting from the storage of spent fuel. No aesthetic or scenic resources in the vicinity of the Site or on the Site would be affected by the operation of the storage area because existing industrial use areas would be used to store the spent fuel. The visual quality of the area would not be affected since the storage area would be compatible with the landscape character of the Kesselring Site. There are no particulate air emissions associated with storage of naval spent nuclear fuel and thus no visibility impacts are expected.

5.1.5.6 Geology

The operation of the naval spent nuclear fuel storage area at the Kesselring Site is not expected to affect the geologic character or resources of the region. If an alternative were selected that required a dry container storage area to be constructed, the ground would only be excavated as necessary to prepare the surface. This would not affect the geological characteristics of the underlying layers nor the characteristics of an aquifer or vadose zone. For the alternative of storing fuel in a water pool facility, the ground surface would need to be excavated to a depth of approximately 40 feet. This excavation would not affect the geological characteristics of the area.

5.1.5.7 Air Resources

5.1.5.7.1 Radiological Consequences.

If the alternative where naval spent nuclear fuel would be stored in dry storage containers were to be selected, no airborne radioactivity releases would be expected to occur as a result of normal storage operations. The naval spent nuclear fuel would be contained such that at least two barriers exist to prevent fission products from becoming airborne. These barriers would retain the naval spent nuclear fuel in an air-tight containment until it is moved to a permanent storage site and there would be no airborne radioactive material released from routine operations for this method of storage. The only radiation exposure would be direct radiation from the array of filled storage containers. The filled storage containers would be fenced off and shielded if necessary such that there would be no distinguishable effect on the current radiation readings at the site perimeter.

For the alternative where naval spent nuclear fuel would be stored in a water pool, airborne radioactivity emissions are expected to be considerably less than that identified for the Idaho National Engineering Laboratory (INEL) Expended Core Facility (ECF) because the water pool size would be smaller, no naval spent nuclear fuel inspection operations beyond visual examinations would be conducted, and no shielded cell operations would be conducted at the Kesselring Site. To conservatively estimate the radiological consequences, airborne releases based on ECF releases from 1991 are used. The radiological source term used and the detailed calculations performed to determine normal releases are provided in Attachment F.

The radiation exposures to human beings due to estimated radionuclide releases to the atmosphere and direct radiation from the stored naval spent nuclear fuel at the Kesselring Site for both the alternative involving water pool storage and the alternative involving dry storage were calculated as described in Attachment F.

A person on the Kesselring Site boundary at the location where the largest exposures would be received was used as the hypothetical maximally exposed off-site individual (MOI) for postulated releases of radioactive material from the stored naval spent nuclear fuel. The population data used to calculate population doses were taken from 1990 census data provided by the U.S. Census Bureau. Meteorology data were obtained as described in Attachment F. Estimated exposures to workers were also calculated.

The hypothetical exposures calculated are based on an exposure to the estimated average effluents and the direct radiation exposure for one year from the naval spent nuclear fuel stored at the Kesselring Site. The calculations include the external effective exposure equivalent from the ground deposition, deposition to surface water, and air immersion pathways and the 50-year committed effective exposure equivalent from internal exposure through the ingestion and inhalation

pathways.
All pathways were considered for the persons potentially exposed, except that the ingestion pathway was omitted for the workers at Kesselring because they do not grow their food on-site. Solubilities which would produce the highest calculated exposures were chosen for internal exposure factors. Values for human dietary consumption patterns were taken from "Age Dependent Values of Dietary Intake for Assessing Human Exposures to Environmental Pollutants" (Rupp 1980). The hypothetical exposures calculated can be converted into a risk of fatal cancer or a risk of non-fatal health detriments (e.g., non-fatal cancers, hereditary defects) based on recommendations of the International Commission on Radiological Protection (ICRP 1991).

Attachment F summarizes the calculated exposures and fatal cancers to the workers, the maximally exposed off-site individual (MOI), and the population from airborne releases of radioactivity and direct radiation exposure in one year for each location and storage mode. Section 3.7 provides a comparison of the annual number of fatal cancers calculated for the general population for each location and alternative.

The number of fatal cancers calculated is so small that there would be essentially no fatal cancers resulting from the storage of naval spent nuclear fuel during the time it could reasonably be expected to continue to be stored. Putting this into perspective, it could be stated that one member of the population might experience a fatal cancer due to incident-free storage of naval spent nuclear fuel at the Kesselring Site if operations continued for 24,400 years.

5.1.5.7.2 Non-radiological Consequences.

As noted in Attachment F, no increase in non-radioactive airborne emissions would be expected to result from naval spent nuclear fuel storage area operations. Storage area operations would not involve use of carcinogenic toxins, criteria pollutants, or other hazardous toxic chemicals except for small quantities of industrial cleaning agents and paint thinner that may be used for housekeeping and cleanliness control and these would be the same as those already used at the Kesselring Site. Consequently, there would be no impact on ambient air quality as a result of implementing any of the alternatives at the Site.

If an alternative were to be selected that required a storage facility to be constructed or renovated, fugitive dust emissions would be expected to result from excavation operations. The quantity of dust generated would be small, consistent with typical excavation activities and controlled within local requirements for dust control.

5.1.5.8 Water Resources

5.1.5.8.1 Radiological Consequences.

Naval spent nuclear fuel storage operations at the Kesselring Site would not result in discharges of radioactive liquid effluents during routine operation regardless of the alternative selected for storage of naval spent nuclear fuel. The health effect due to fallout of nuclides released to the air onto the surface water is included in the analysis results discussed in Section 5.1.5.7. The air fallout impact is so small that there would be no distinguishable radiation levels in the water.

The Kesselring Site does not reside in the 100 or 500 year floodplain. Consequently, the floodplain would not be impacted by spent naval nuclear fuel storage and examination activities at the Site.

5.1.5.8.2 Non-radiological Consequences.

Other than chemicals used to maintain the storage area, no hazardous wastes would be generated by the storage of naval spent nuclear fuel at the Kesselring Site. Any hazardous liquid effluents that may be generated at the storage area would be disposed of at an Environmental Protection Agency approved disposal site.

The only source for liquid discharges from the naval spent nuclear fuel storage operations to the environment consists of storm water runoff which would be consistent with the type of discharges associated with common light industrial facilities and related activities. It can be concluded that there would be no impact to the human environment due to runoff water from the naval spent nuclear fuel storage area.

The increased water usage under any of the alternatives would be negligible compared to the existing Site demand.

5.1.5.9 Ecological Resources

There are no known habitats for threatened or endangered species within the Kesselring Site and no major changes to the industrial environment are planned. Therefore, no ecological impacts to the region would result from selection of any of the alternatives.

The conceptual location where naval spent nuclear fuel would be stored is illustrated in Attachment D. This location is within an existing industrial complex and is surrounded by buildings and paved areas. The industrial nature of the Kesselring Site and the fact that the land has already been disturbed from its natural state by earlier activities mean that plant or animal species sensitive to disturbance by human activities would not be expected to be present. Therefore, there would be no ecological impacts associated with construction or operation of a spent nuclear fuel storage area at this location. The radiological controls that are in effect at the Kesselring Site ensure that the radiation levels in the vicinity of the Site are maintained at or near natural background. Since these same controls would be applied to spent nuclear fuel activities, no ecological effects due to radioactive material would be expected to occur.

5.1.5.10 Noise

The Kesselring Site is an existing light industrial-type environment characterized by noise from truck and automobile traffic; diesel-powered equipment; and continuously operating transmission lines for steam, fuel, water, and related pumping systems for these and other liquids. There would be no increase in ambient noise associated with any of the alternatives. Therefore, no noise impacts would be expected to occur.

5.1.5.11 Traffic and Transportation

Shipments of radioactive materials in the Naval Nuclear Propulsion Program are required to be made in accordance with applicable regulations of the U. S. Department of Transportation, U.S. Department of Energy, and the U.S. Nuclear Regulatory Commission. The purpose of these regulations is to ensure that shipments of radioactive material are adequately controlled to protect the environment and the health and safety of the general public. These regulations are applicable to all radioactive material shipments and provide requirements for the container design, certification, and identification as applicable for the specific quantity, type, and form of radioactive material being shipped. Naval shipping container design requirements invoke shielding and integrity specifications and meet all regulatory requirements. They provide for testing of container designs, training and qualification of workers who construct containers, and quality control inspections during fabrication to ensure that the containers will meet their design requirements. A detailed description of the shipping containers used for naval spent nuclear fuel shipments is provided in Attachment A. A description of the impacts from normal and accident conditions associated with transportation of naval spent nuclear fuel is provided in Attachment A.

5.1.5.11.1 Regional Infrastructure.

The alternatives under consideration are described in Section 3. The No Action alternative or the first variation of the Decentralization alternative would store the naval spent nuclear fuel on-site. This alternative would reduce the number of rail shipments from the shipyard or prototype site compared to the past practice of transporting all naval spent nuclear fuel to INEL. The second variation of the Decentralization alternative would ship about 10 percent of the naval spent nuclear fuel to Puget Sound. This would have some transportation impact, but not as much as transporting all naval spent nuclear fuel off-site. The third Decentralization alternative ships all naval spent nuclear fuel to INEL, examines it, and returns it to the original shipyard or prototype site. This alternative involves more transportation than the previous practice of transporting naval spent nuclear fuel to INEL, since the naval spent nuclear fuel is not returned from INEL to the original site. The 1992/1993 Planning Basis alternative, the Regionalization at INEL alternative, or the Centralization at INEL alternative would involve the same transportation as has been required in the past, namely transportation to INEL and retention there. The Centralization alternative at the Hanford Site would result in more transportation impact than any of the previous alternatives, due to the distances and population distribution between Hanford and the shipyards and prototypes. The Centralization alternative at the Savannah River Site would result in the most transportation impact of naval spent nuclear fuel of any of the alternatives.

5.1.5.11.2 Site Infrastructure.

The alternatives associated with storage of naval spent nuclear fuel at the Kesselring Site would have no impact on local highway traffic because any increase in the work force would represent a very small incremental increase in overall traffic to and from the Site. There would be no change in the internal traffic at the Kesselring Site because naval spent nuclear fuel is temporarily held on-site even when it is transported off-site.

5.1.5.12 Occupational and Public Health and Safety

Detailed analyses of incident-free naval spent nuclear fuel transportation and storage and handling impacts on worker and public health are described in Attachment A (transportation) and Attachment F (storage and inspection). The transportation analysis results, and the storage and handling analysis are summarized separately in the following subsections.

5.1.5.12.1 Incident-free Transportation Occupational and Public Health and Safety.

The radiological and non-radiological effects associated with the incident-free transportation of naval spent nuclear fuel and test specimens have been assessed for the general population, transportation workers, and the hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancers as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. The details of the transportation analysis are provided in Attachment A.

5.1.5.12.2 Incident-free Occupational and Public Health and Safety During Naval Spent

Nuclear Fuel Storage and Handling.
The public health and safety impacts of radioactivity releases and direct radiation from storage of naval spent nuclear fuel were analyzed as discussed in Section 5.1.5.7 and Attachment F. Attachment F summarizes the results of the analysis of radioactivity releases and direct radiation from stored naval spent nuclear fuel. This analysis shows that the exposure to the worker and maximally exposed off-site individual from stored naval spent nuclear fuel would result in far less than one fatality per year. For perspective, it could be stated that one member of these population groups might experience a fatal cancer due to storage of naval spent nuclear fuel at the Kesselring Site if operations continued for 24,400 years.

Attachment F also discusses toxic chemical issues for naval spent nuclear fuel handling and storage. Attachment F concludes that there would be no additional types or volumes of chemicals required at the shipyards or prototype site for naval spent nuclear fuel storage. Therefore, there is no incident-free non-radiological impact resulting from storage of naval spent nuclear fuel at the shipyards or prototype site.

Projections of the number of occupational accidents that might occur during construction and operation of naval spent nuclear fuel storage and examination facilities have been made for each alternative. These projections are presented in Attachment F. Based on the results of these projections, it is concluded that the number of occupational fatalities and injuries or illnesses for construction activities and storage and examination operations would be very small for any alternative.

No public or occupational radiological health and safety impacts would be expected to result from naval spent nuclear fuel storage area construction activities since the construction would not involve radioactive work.

5.1.5.12.3 Incident-free Occupational and Public Health and Safety Effects on Environ-

mental Justice Due to Naval Spent Nuclear Fuel Storage and Handling.
As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from normal operations associated with the management of naval spent nuclear fuel at the Kesselring Site would be small under any of the alternatives considered. For example, it is unlikely that a single fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to normal operations or accident conditions for any of the alternatives considered present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is true for normal operations because the effects of routine operations are so small. It is also true for accident conditions because the consequences of any accident would depend on the random conditions at the time it occurred, and the wind directions at the Kesselring Site do not display any strongly dominant direction. Similarly, the conclusion is not affected by concerns related to subsistence consumption of fish or game since environmental monitoring in the vicinity of this relatively small and restricted site has shown no detectable difference in the amounts of radioactivity present in the environment from levels in similar parts of the region.

To place the impacts on environmental justice in perspective, the risk associated with routine naval spent nuclear fuel management operations under any of the alternatives considered would be less than one fatality per year for the entire population. For comparison, in 1990 there were approximately 510,000 cancer deaths in the United States population and there were about 64,000 cancer deaths among people of color in the U. S. Even if all of the impacts associated with one of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would be unlikely to experience a single additional cancer fatality in any year. Therefore, the cancer risk for that population from naval spent nuclear fuel management would not constitute a disproportionately high and adverse impact on human health or the environment. The same conclusion can be drawn for low-income groups.

5.1.5.13 Utilities and Energy

If an alternative associated with storage of naval spent nuclear fuel at the Kesselring Site were to be selected, construction and operation of a naval spent nuclear fuel storage facility would not be expected to require a large expenditure of utilities and energy resources. Operation of the storage facility would likely require only a small amount of electricity for lighting and to support industrial equipment necessary to move spent nuclear fuel containers (cranes etc.). Construction activities would require quantities of water and electricity typical of any small to medium size construction project. Alternatives associated with water pool storage would require heating, ventilation, water, and electrical systems suitable for a work environment and to properly filter and exhaust the airborne discharges to the atmosphere. The utility and energy demands would be less than that required to operate ECF (10,000 MWh per year) (Section 5.2.13) since the water pool for naval spent nuclear fuel storage would be smaller and no inspections would be performed. The amount of utilities and energy expected to be consumed as a result of dry storage would be a small incremental increase in the total amount of utilities and energy used at the Kesselring Site and would not result in any discernible environmental consequences.

5.1.5.14 Facility and Transportation Accidents

5.1.5.14.1 Facility Accidents. There has never been an accident in the history of the Naval

Nuclear Propulsion Program that resulted in a significant release of radioactivity to the environment or that resulted in radiation exposure to workers in excess of abnormal occurrence limits on exposures as defined by the U.S. Nuclear Regulatory Commission. A description of potential accidents considered and a summary of the accident analyses that were conducted with regards to the storage of naval spent nuclear fuel are contained in Attachment F.

5.1.5.14.1.1 Radiological Accidents. Section 3.7.3 provides a summary of the impacts

due to the most severe accidents considered for each site. The facility accident with the greatest potential impact at the Kesselring Site involves an airplane crash. An accident of this magnitude would result in 7.5 fatal cancers to the general population over 50 years, as described in Attachment F. The likelihood of an airplane crash is 1 x 10-7. The facility accident with the greatest risk involves accidental drainage of the water pool. The drained water pool accident would result in less than one fatality over 50 years, but the likelihood of occurrence is 1 x 10-5.

5.1.5.14.1.2 Non-radiological Accidents. As discussed in detail in Attachment F, the

limiting hypothetical non-radiological accident for naval spent nuclear fuel storage in a water pool at a shipyard or prototype location would be a diesel fuel spill and fire. A catastrophic failure of a diesel fuel storage tank that might be used for an emergency diesel generator to provide backup electrical power was postulated to occur, resulting in the spilling of the entire quantity of diesel fuel with a subsequent fire. The fire would generate the following toxic chemicals:

- Carbon monoxide
- Oxides of nitrogen (90% nitric oxide and 10% nitrogen dioxide)
- Lead
- Sulfur dioxide.

Measures would be taken to reduce the health impacts of potential releases of toxic materials. These measures would involve controls to protect both workers and the general public. The naval shipyard and prototype sites have emergency planning, emergency preparedness, and emergency response programs in place to protect both workers and the public, and involve established resources such as warning communications, fire departments, and emergency command centers.

The airborne concentrations of the combustion products listed above, resulting from the fire, were calculated at the locations of the on-site individuals, an individual at the site boundary, and the general population within a 50-mile radius of the facility. Detailed results are presented in Attachment F. If the accidental fire that has been hypothesized were to actually occur, the safety measures that would be in place would ensure no adverse health impacts to the general public and minimal health impacts to the workers.

5.1.5.14.2 Transportation Accidents.

Shipments of radioactive materials associated with naval spent nuclear fuel have never resulted in any measurable release of radioactivity to the environment (NNPP 1994a). There have never been any significant accidents involving the release of radioactive material during shipment since the Naval Nuclear Propulsion Program began. The effects of potential transportation accidents during the various stages of transportation of naval spent nuclear fuel are presented in Attachment A.

The health effects associated with accidents during shipments of naval spent nuclear fuel and test specimens have been assessed for the general population and the hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancers as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. The details of the transportation analysis are provided in Attachment A.

5.1.5.14.3 Other Impacts of Accidents.

In addition to the possible human health effects associated with facility or transportation accidents described in the preceding sections, other effects such as the impacts on socioeconomics and land use in the area and the costs of cleanup have been estimated in order to develop a perspective and to evaluate potential differences among alternatives. The analyses described in Attachment F showed that an area ranging from about 8 acres extending approximately a quarter mile (for an inadvertent criticality accident) to about 110 acres extending approximately 0.9 mile (for a large airplane crashing into a dry storage container) might be contaminated to the point where exposure could exceed 100 millirem per year. Beyond these distances, exposure would be less than 100 millirem per year, the Nuclear Regulatory Commission's standard for protection of the general population from radiation. Persons who live in this area might be evacuated or otherwise experience restrictions in their daily activities for a brief period, and those who work at locations within this area might be prevented from going to their jobs until measures had been taken to reduce the potential for exposure. It should be noted that all of the affected area within about three-quarters of a mile from the spent nuclear fuel facility would be inside the boundaries of the Kesselring Site.

An accident might result in short-term restrictions on access to a relatively small area, but there would be no enduring impacts on cultural or similar resources or concerns such as Native American rights or interests, partially because the area involved would be small and partly because all remedial actions would be conducted in a careful, controlled manner in full compliance with applicable laws and regulations. The area would vary only slightly among the alternatives considered. Overall, the risks are small so these considerations do not assist in distinguishing among alternatives.

Facility or transportation accidents associated with any of the alternatives would not have an appreciable effect on the ecology of the area, considering the potential for human health effects and the amount of land which might be affected, as described in earlier parts of this section. There is little consensus among scientists on methods for estimating the effects of radiation on ecological resources such as plant or animal life, but since human health effects for all the accidents analyzed are small and most plants and animals are not thought to be more sensitive to radiation than human beings, the small impacts on human health provide an indication that the impacts on animal and plant species in the area would also be small for all alternatives considered. Similarly, since the areas which might be contaminated to measurable levels by chemicals or radioactive material during the hypothetical accidents would be relatively small, any effects on the ecology would be limited to small areas. There are no endangered or threatened species unique to the area surrounding the federally owned site, so an accident would not be expected to result in destruction of any species for any of the alternatives considered. The effects of any accident related to any of the alternatives and any cleanup which might be performed would be localized in a small area which extends only a short distance beyond the boundaries of the federally owned site and thus would not be expected to appreciably affect the potential for survival of endangered or threatened species which might occupy wetlands or other habitat in the Saratoga area. Consequently, evaluation of impacts of accidents on ecological resources does not help to distinguish among alternatives.

5.1.5.14.4 Effects of Accidents on Environmental Justice Due to Naval Spent Nuclear Fuel Storage and Handling.

As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from facility or transportation accidents associated with the management of naval spent nuclear fuel at the Kesselring Site would be small under any of the alternatives considered. For example, it is unlikely that a single additional fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to an accident for any of the alternatives considered would present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects from accidents associated with the management of naval spent nuclear fuel would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is because the consequences of any accident would depend on the random conditions in effect at the time an accident occurred, and the wind directions at the Kesselring Site are highly variable with no strongly dominant direction.

To place the impacts on environmental justice in perspective, the risk associated with accidents caused by naval spent nuclear fuel management under any of the alternatives considered would amount to less than one additional fatality per year for the entire population. For comparison, in 1990 there were approximately 40,000 traffic fatalities in the United States population and there were about 7,400 deaths caused by traffic accidents among people of color in the U. S. Even if all of the additional cancer deaths associated with an accident involving any of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would experience less than one additional fatal cancer per year. The same conclusion can be drawn for low-income groups.

5.1.5.15 Waste Management

The alternative in which naval spent nuclear fuel is stored at the Kesselring Site would produce limited amounts of solid municipal waste, solid low-level radioactive wastes, and hazardous wastes.
In addition, no transuranic or high-level radioactive wastes would be generated by spent nuclear fuel activities at the Kesselring Site under any alternative. The quantity of industrial wastes generated would be small and most likely consist of industrial cleaning agents of the type normally encountered at the Site. Small quantities of sanitary wastes would result from the additional work force but this volume would be small. The wastes produced from the storage of naval spent nuclear fuel would be controlled and minimized in accordance with the existing waste management programs at the Kesselring Site. The amount of additional wastes generated would be minimal compared to the existing baseline and would not cause any adverse impacts to public health and safety and the environment in the vicinity of the Kesselring Site.

5.1.5.16 Cumulative Impacts

5.1.5.16.1 Radiological Cumulative Impacts. Spent nuclear fuel storage at the Kesselring Site

would not result in discharges of radioactivity in liquid effluents during routine operations regardless of the alternative selected. Therefore, there would be no incremental addition of radioactivity to surface or ground water as a result of normal operations for any alternative. For alternatives involving the storage of spent nuclear fuel in dry storage and shipping containers, no airborne radioactivity emissions are expected, so there would be no cumulative air quality impacts associated with these storage methods. Consequently, the only radiological cumulative impacts that would result from dry storage alternatives would be due to direct radiation exposure from the stored containers of spent nuclear fuel.

For alternatives involving the storage of naval spent nuclear fuel in water pools, there would be no discernible direct radiation exposure to the public from the fuel elements due to the shielding provided by the water in the pool. Therefore, any cumulative impacts which would result from water pool storage would be primarily due to airborne emissions, and the addition of these emissions would cause an indiscernible change in the emissions in the area (see Section 5.1.5.7). Current operations at the site are in compliance with Title 40, Code of Federal Regulations, Part 61, "National Emission Standards for Hazardous Air Pollutants." Cumulative air emissions would not threaten to exceed any applicable air quality requirement or regulation, either federal, state, or local in radiological and non-radiological categories.

A summary of the cumulative radiological impacts is provided in the following section.

An overview of the historical radiological impacts from naval nuclear operations at the Kesselring Site and from transportation of naval spent nuclear fuel is provided in Section 4.1.5.12 and detailed analyses are provided in Attachments F and A. Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

The radiological impacts associated with the alternatives where naval spent nuclear fuel would be stored at the Kesselring Site are very small and are described in Section 5.1.5.12, with the detailed results of analyses provided in Attachment F. In order to calculate cumulative impacts for the period between 1995 and 2035, the annual radiological impacts associated with each location and alternative were summed over 40 years. The results of this summation are tabulated in Tables 3-5 and 3-6 of Section 3.

The cumulative transportation impacts for the population groups from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated and are very small. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A and summarized in Section 3.7.4.

The total exposure to the population in the vicinity of the Kesselring Site from all of the alternatives considered would be approximately 3.28 person-rem. This means that there would be much less than one fatal cancer from these operations over the entire 40-year period evaluated. The total exposure to a theoretical maximally exposed off-site individual living at the shipyard boundary for the entire 40-year period would be 2.7 x 10-4 rem due to the alternative resulting in the largest exposure. This maximally exposed off-site individual would have a 1.4 x 10-7 risk of contracting a fatal cancer during his or her lifetime due to storage of spent nuclear fuel. When existing site radiological impacts due to naval nuclear operations are added to the impacts of the most limiting spent nuclear fuel alternative, the exposure to the population would be 5.6 person-rem and to the maximally exposed off-site individual would be 4.8 x 10-4 rem. This still results in much less than one fatal cancer in the population and the risk of the maximally exposed off-site individual contracting a fatal cancer during his or her lifetime is 2.4 x 10-7.

The total exposure related to naval spent nuclear fuel activities to a worker assumed to be working continually 100 meters from the spent nuclear fuel under the alternative resulting in the largest exposure is 2.4 x 10-2 rem accumulated over 40 years. That corresponds to a fatal cancer risk of 9.6 x 10-6 during the worker's lifetime. The exposure to the same worker when existing site radiological impacts due to naval nuclear operations are added to the spent nuclear fuel exposure is 2.6 x 10-2 rem over 40 years which corresponds to a fatal cancer risk of 1.1 x 10-5 during the worker's lifetime. The impacts associated with transportation of naval spent nuclear fuel for all of the alternatives considered would be similarly low.

No contribution to cumulative impacts from accidents involving naval spent nuclear fuel has been included in the analyses presented in this Environmental Impact Statement because there has never been a nuclear reactor accident, criticality accident, transportation accident, or any release of radioactivity which had a significant effect on the environment.

Sections 4.1.5.14 and 5.1.5.15 describe the management of low-level radioactive waste and mixed waste at the site. The volume of low-level radioactive wastes which would be generated under the alternatives has not been calculated. However, considering the nature of radiological work that would be associated with spent nuclear fuel storage activities, the amount of low-level radioactive waste produced during spent nuclear fuel activities would be much less than 20 percent of the current site generation rate (215 m3 per year). This additional radioactive waste would not introduce any changes to the Site's waste management practices. The small amount of additional material involved would not impose any discernible additional stress on the capacity of the radioactive waste burial ground. Therefore, any cumulative impacts associated with the generation and disposal of additional low-level wastes would be very small.

Since no mixed, transuranic, or high-level radioactive wastes would be generated by spent nuclear fuel activities at the Kesselring Site under any alternative, there would be no cumulative impacts associated with these materials.

5.1.5.16.2 Non-radiological Cumulative Impacts.

An overview of the historical non-radiological impacts from naval nuclear operations at the Kesselring Site and from transportation of naval spent nuclear fuel is provided in Section 4.1.5.12 and detailed analyses are provided in Attachments F and A. Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no non-radiological cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

The non-radiological impacts associated with the alternative where naval spent nuclear fuel would be inspected or stored at the Kesselring Site are described in Section 5.1.5.12, with the detailed results of analyses provided in Attachment F. As summarized in Section 5.1.5.12, there would be no additional chemicals required at the prototype site for naval spent nuclear fuel storage and therefore no non-radiological impacts from normal operations. Consequently, no cumulative impacts to air quality or water resources would result since the incremental addition of chemicals at the Site that might result from naval spent fuel activities would be very small. There are no current environmental problems associated with these materials.

The non-radiological cumulative transportation impacts for the population from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A. The non-radiological impacts associated with the transportation and storage of naval spent nuclear fuel for all of the alternatives considered would be low.

No cumulative land use impacts would be expected to occur as a result of spent nuclear fuel storage. The land that would be dedicated for this purpose is on existing federal property and situated in an industrial setting which has already been disturbed from its natural state (about 50 acres are developed land). The conversion of this space for storage of spent nuclear fuel would not result in the need to disturb undeveloped land or for additional land to be added to the federally owned property in the foreseeable future.

From a socioeconomic perspective, the introduction of naval spent nuclear fuel activities at the Kesselring Site would create a small number of additional jobs and could have a very small cumulative socioeconomic impact. The site currently employs approximately 1450 civilian personnel. No site employment has been associated with spent nuclear fuel activities in the past since spent nuclear fuel activities have not been conducted at the site. An average of approximately 1 to 24 additional jobs might be added as a result of possible spent nuclear fuel activities in the future. The peak number of additional jobs created at the site in any given year would be approximately 81, which is associated with construction and operation of a water pool facility for storage of spent nuclear fuel. Considering that the regional labor force consists of approximately 176,600 workers, the additional number of added jobs under any alternative would have little or no discernible socioeconomic impact. These jobs would be filled either from within the existing Site work force or from the available regional labor force without discernible effect. There are no foreseeable future projects planned at the Site and no known projects planned in the region that would cause the small number of workers involved in naval spent nuclear fuel activities to become an important impact.

The cumulative impacts associated with non-radiological waste management are likewise expected to be small. As stated previously, any industrial wastes generated from naval spent nuclear fuel storage would be small and limited to industrial cleaning agents of the type normally encountered at the Kesselring Site. The volume of municipal solid wastes and sanitary wastes which would be generated is expected to be proportional to the number of additional workers added, and this small incremental increase would not be discernible. The amount of additional non-radiological wastes generated would not introduce any changes to the Site's waste management practices and would not impose any additional stress on the capacity of on-site or off-site waste disposal or treatment facilities. Therefore, any cumulative impacts associated with the generation and disposal of additional wastes would be very small. There are no current environmental problems associated with these types of waste.

5.1.5.17 Unavoidable Adverse Effects

There are no discernible unavoidable adverse effects associated with the implementation of any of the alternatives and none which would help to choose among the alternatives. The alternative in which naval spent nuclear fuel is stored at the Kesselring Site would cause the public to be exposed to small amounts of radiation, described in Section 5.1.5.12, and would result in less than one health effect in the entire population surrounding the Kesselring Site. Similarly, continued operation of the storage facility would produce limited amounts of solid municipal waste and solid low-level radioactive waste. These amounts of waste would not produce any major impacts in the vicinity of the Kesselring Site. There will be no changes to the ecological, cultural, geological, and aesthetic resources due to the implementation of any of the alternatives. There would also be no expected impact on ambient noise levels.

5.1.5.18 Irreversible and Irretrievable Commitments of Resources

The only irreversible and irretrievable commitment of resources that results from the alternative in which naval spent nuclear fuel would be stored at the Kesselring Site would be the money that would be spent by the federal government to construct the necessary facilities. The total cost of storing spent naval nuclear fuel at the shipyards and prototype ranges from approximately $1.5 billion to $5.7 billion. This cost represents the total cumulative cost over the 40-year period for all of the shipyards and prototype. This cost includes construction costs of the new storage facilities, and, depending on the alternative selected, the operation of a limited examination facility at Puget Sound Naval Shipyard combined with the costs associated with shutting down ECF, or the operational costs of the INEL-ECF. The major expense in the highest cost alternatives is the procurement of shipping containers. Refer to Section 3.7 for a comparison of the total cumulative costs among alternatives.

5.2 IDAHO NATIONAL ENGINEERING LABORATORY

5.2.1 Overview of Environmental Impacts

The following sections discuss the potential environmental consequences at the Idaho National Engineering Laboratory (INEL) associated with the choice of alternatives for naval spent nuclear fuel management at the Expended Core Facility (ECF). The environmental consequences are based on the fact that the ECF is currently in existence and operating within the perimeter of the Naval Reactors Facility (NRF) at INEL. Volume 1, Appendix B provides an assessment of the environmental impacts at INEL resulting from the full range of spent nuclear fuel activities. This includes the impacts resulting from "ECF-related" activities, which are discussed below (i.e., the impacts resulting from the transportation, receipt, handling, and examination of naval spent nuclear fuel), as well as the impacts associated with the spent nuclear fuel operations at the Idaho Chemical Processing Plant (i.e., the storage of both naval and non-naval spent nuclear fuel and other non-naval spent nuclear fuel operations).

Review of the environmental effects of operation of the Expended Core Facility at INEL for the receipt and examination of naval spent nuclear fuel has shown that the impact on the environment associated with this work is very small. The largest effect in the vicinity of INEL associated with the selection of any alternative for examination of naval fuel is the economic impact of the jobs which are retained or lost at ECF. The differences in all other impacts in the vicinity of INEL for the available alternatives are very small or non-existent.

5.2.2 Land Use

The plan for all three naval plant prototypes at NRF is that they will all be shut down, defueled, and placed in safe storage until they are decommissioned. Operations at the ECF could continue or cease, depending upon the alternative selected. None of the prototype plants or the ECF, if operations cease, is planned to be decommissioned during the next 10 years; therefore, this land will not be available for other uses in the near future. Native American rights and interests would not be modified by construction or operations associated with any of the alternatives considered.

5.2.3 Socioeconomics

Approximately 500 engineers, technicians, clerical, and maintenance personnel are employed in the receipt and examination of naval spent nuclear fuel at ECF or in direct support of these activities. Table 5.2-1 provides a summary of the direct jobs which would be associated with the ECF if an alternative is selected which closes ECF, while Table 5.2-2 provides a summary of the direct jobs associated with the continued operation of ECF. As shown in Table 5.2-1, there is an increase in workers in the first three years to handle the shipment of containers which had been in storage at the shipyards and prototype during the preparation of this Environmental Impact Statement. The number of workers then decreases steadily to a final caretaker work force of 10. The increase in work force in the first three years shown in Table 5.2-2 includes construction workers for the completion of the Dry Cell Facility in addition to the operations work force increase discussed above.

Table 5.2-1. Summary of direct jobs (closure of INEL-ECF).

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Direct Jobs	550	550	550	500	350	100	10	10	10	10

Table 5.2-2. Summary of direct jobs (operation of INEL-ECF).

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Direct Jobs	574	574	550	500	500	500	500	500	500	500

5.2.4 Cultural Resources

None of the alternatives considered would impact known archaeological or Native American sites. Procedures which comply with all applicable laws and regulations would be implemented to protect previously undetected archaeological and cultural sites.

5.2.5 Aesthetic and Scenic Resources

The entire Naval Reactors Facility is difficult to see from any point accessible to the public so aesthetic and scenic resources in the vicinity of INEL will not be affected by the alternative selected for receipt and handling of naval spent nuclear fuel at ECF. Even if NRF could be observed, the only action which would alter the landscape at NRF is the dry cell extension for spent fuel handling to ECF envisioned under the 1992/1993 Planning Basis alternative and this addition to the existing ECF building would be architecturally compatible with the NRF buildings.

5.2.6 Geology

The geology in the vicinity of the INEL will not be affected by the alternative selected for receipt and handling of naval spent nuclear fuel since no changes which could impact the geology would occur under any of the alternatives.

5.2.7 Air Resources

Small quantities of radioactivity are contained in the air released from ECF and prototype plant operations at NRF. The annual releases from ECF total approximately 1.1 curies, composed primarily of 0.30 curie of krypton-85, 0.70 curie of carbon-14, 0.094 curie of tritium, 0.000011 curie of combined strontium-90 and yttrium-90, and 0.0000048 curie of iodine-131. These releases at NRF would be reduced to near zero if an alternative which ends examination of naval spent nuclear fuel at ECF were selected. This reduction will occur approximately three years after the last fuel is received.

The principal sources of non-radioactive industrial gaseous effluents are air from offices, water vapor from cooling towers, and fuel combustion products from the three steam generating boilers used for heating. Since the boilers are used for generating steam for heating and it would be necessary to heat and maintain the ECF building whether naval spent nuclear fuel is shipped to INEL or not, the airborne effluents at NRF would be little affected by the alternative selected.

Asbestos-containing material is present at NRF, but, as a result of the well-controlled conditions with regard to asbestos at NRF, releases will be unaffected by the alternative selected.

5.2.8 Water Resources

No radioactive liquids are discharged to the environment at NRF. Consequently, the alternative selected would have no effect on releases of radioactive liquids at NRF.

Since the water released to the industrial waste ditch does not include any effluents from ECF, the discharges to the ditch would be unaffected by the choice of alternatives. Operation of ECF produces about 25% of the total NRF sewage discharge and the ECF discharge would be reduced to approximately zero if the people currently performing spent fuel examinations in that facility were no longer employed at NRF.

No hazardous wastes are disposed of at the NRF site and all solid and liquid hazardous wastes are transported by vendors to treatment, storage, and disposal facilities approved by the Environmental Protection Agency and operating under approvals or permits granted by state and federal regulatory agencies. The small amount of hazardous waste produced during ECF operation produces no effect on the environment in the vicinity of INEL, so the alternative selected would have no impact on water quality in this area.

Annual ECF water consumption is about 2.5 million gallons. The alternative selected would have no discernible effect on water usage, because the ground-water withdrawn for ECF operations is small in comparison to the total INEL water consumption. ECF operation has virtually no effect on surface waters.

A flood at ECF due to overflow of any surface water within the INEL boundaries is a low probability event. Flooding of the ECF building is possible should the Mackay Dam fail; however, there is adequate time following the dam break until the flood water reaches NRF to complete emergency procedure preparations. For more information refer to Attachment B.

5.2.9 Ecological Resources

Ecological resources (i.e., the terrestrial ecology, wetlands, aquatic ecology, and endangered and threatened species) in the vicinity of INEL will not be affected by any alternative selected since no additional land at the NRF site will be disturbed under any alternative.

5.2.10 Noise

The small amount of noise generated by work at ECF would cease several years after an alternative which stopped shipment of spent naval nuclear fuel were selected since ECF operations would cease. However, since this noise cannot be discerned beyond the site boundaries, the alternative selected would have no discernible impact on noise in the vicinity of INEL.

The similarly small amount of noise associated with railcar movement produced during shipment of the naval spent nuclear fuel from shipyards to ECF would cause the alternative selected to have no discernible impact on railcar noise generation. This is the case because the less than 50 railcars involved each year represent a minute fraction of the rail traffic in any area affected and the noise is indistinguishable from that produced by other rail traffic.

5.2.11 Traffic and Transportation

Traffic and transportation in the vicinity of INEL associated with naval spent nuclear fuel receipt, handling, and examination would essentially cease if an alternative which ended such operations at ECF were selected. This would cause approximately 400 truck deliveries per year to be eliminated. The reduction in personnel at ECF associated with cessation of these activities would cause approximately 22 fewer buses to be needed to transport them to and from the site each day. None of the alternatives considered would increase traffic or the need for transportation in the vicinity of INEL.

If the ECF operation continues at the INEL, routine shipments of naval spent nuclear fuel would be resumed to the site in certified shipping containers. Low-level waste generated at ECF and hazardous waste would continue to be moved from ECF to a disposal facility.

5.2.12 Occupational and Public Health and Safety

5.2.12.1 Occupational Health and Safety. Radiological and non-radiological impacts of ECF

operations on occupational health and safety are assessed separately in terms of radiological and non-radiological effects.

Radiation exposures to workers at ECF have averaged approximately 100 millirem per year, compared to the limit of 5000 millirem per year specified by The Code of Federal Regulations, Title 10, Part 20. The total radiation exposure to workers at ECF makes up about 30% of the occupational exposure to radiation experienced by workers at NRF. Since only about 280 workers at ECF work in radiological areas and the health risk per worker is estimated to be approximately 0.00040 occurrences of fatal cancer per rem of exposure, less than one fatal cancer (approximately 0.45 fatal cancer estimated) could be expected among all ECF workers throughout the rest of their lives due to operation of ECF for an additional 40 years. This means that radiation effects on the health of INEL workers would be virtually unchanged by the alternative selected for examination of naval spent nuclear fuel.

Operations at ECF have resulted in fewer than 210 days of work lost to injuries in the seven years between 1987 and 1993 out of 736 total lost days of work at NRF during that period. Recordable injuries at ECF represented about 12% of the total number of such injuries at NRF during the same period. Consequently, selection of an alternative which ended operation of ECF at INEL might be expected to reduce injuries to workers at NRF by about 10% to 25% due to the reduction in work force. Operation of a replacement for ECF at another Department of Energy (DOE) site would likely result in roughly the same number of injuries to workers at that facility since the safety record at ECF is very good and similar safe working conditions could be established at the new facility.

Projections of the number of occupational accidents that might occur during construction and operation of naval spent nuclear fuel storage and examination facilities have been made for each alternative. These projections are presented in Attachment F. Based on the results of these projections, it is concluded that the number of occupational fatalities and injuries or illnesses for construction activities and storage and examination operations would be very small for any alternative.

Limited quantities of some materials classified as hazardous chemicals are handled at ECF, but the precautions used during the work prevent exposure of the workers to these materials. Therefore, the alternative selected would not be expected to increase or decrease the exposure of

INEL workers to potentially hazardous chemicals.

5.2.12.2 Public Health and Safety. The impact of NRF operations on public health and safety

can also be assessed separately in terms of radiological and non-radiological effects.

The comprehensive INEL site radiation monitoring program (Hoff et al. 1992) shows that radiation exposure to persons who do not work at INEL resulting from all NRF operations is too small to be measured. In order to provide an estimate of the effects of radiation exposure which might be caused by INEL operations, calculations have been performed of the radiological exposures to the member of the general public who might receive the highest exposure (called the maximally exposed individual), to nearby (collocated) workers, to a worker at ECF located approximately 100 meters from the release point, and to the population surrounding the Idaho National Engineering Laboratory. These calculations include all types of radioactive particles or gases released into the atmosphere from the operation of all existing NRF facilities, including ECF. The calculation results and the analysis methods are provided in more detail in Attachment F.

The calculations indicate the risks are so small that there would be essentially no health effects resulting from radioactivity released by all operations at NRF, including ECF during the time it could reasonably be expected to operate. Putting the risk into perspective, it could be stated that one member of the population might experience a fatal cancer due to combined effects of operation of ECF if operations continued as in the past for 260 million years.

The radiological and non-radiological health effects associated with the incident-free transportation of naval spent nuclear fuel and test specimens have been assessed for the general population, transportation workers, and the hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any health effects as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer or detrimental health effect for each alternative. The details of the transportation analysis are provided in Attachment A.

Results of all effluent monitoring confirm that the operation of NRF has no detectable impact on the environment from non-radiological releases (WECNRF 1993). Operations at NRF have had no effect on the groundwater of the Snake River Plain Aquifer, and monitoring results indicate no detectable toxic chemicals, solvents, or laboratory chemicals in the groundwater in the vicinity of NRF. No constituent measured in groundwater in the vicinity of NRF exceeds applicable drinking water standards. The alternative selected for examination of naval spent nuclear fuel would therefore have no effect on non-radiological public health and safety in the vicinity of INEL.

5.2.12.3 Incident-free Occupational and Public Health and Safety Effects on Environ-

mental Justice Due to Naval Spent Nuclear Fuel Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from normal operations associated with the examination of naval spent nuclear fuel at the INEL would be small under any of the alternatives considered. For example, it is unlikely that a single fatal cancer would occur as a result of activities associated with naval spent nuclear fuel examination under any alternative. Since the potential impacts due to normal operations or accident conditions for any of the alternatives considered present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is true for normal operations because the effects of routine operations are so small. It is also true for accident conditions because the consequences of any accident would depend on the random conditions at the time it occurred, and the wind directions at the INEL do not display any strongly dominant direction. Similarly, the conclusion is not affected by concerns related to subsistence consumption of fish or game because of the very small impacts associated with examination of naval spent nuclear fuel.

To place the impacts on environmental justice in perspective, the risk associated with routine operations for naval spent nuclear fuel examination under any of the alternatives considered would be less than one fatality per year for the entire population. For comparison, in 1990 there were approximately 510,000 cancer deaths in the United States population and there were about 64,000 cancer deaths among people of color in the U. S. Even if all of the impacts associated with one of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would be unlikely to experience a single additional cancer fatality in any year. Therefore, the cancer risk for that population from naval spent nuclear fuel management would not constitute a disproportionately high and adverse impact on human health or the environment. The same conclusion can be drawn for low-income groups.

5.2.13 Utilities and Energy

Operations at ECF currently consume approximately 10,000 MWh of electricity each year. However, since the ECF building and associated facilities would have to be maintained during the period covered by this Environmental Impact Statement whether ECF is used for naval spent nuclear fuel examination or not and the spent fuel examinations do not consume particularly large amounts of energy, the consumption of electricity and other energy would not be appreciably affected by the alternative selected. None of the alternatives considered would increase the consumption of energy at INEL.

5.2.14 Facility and Transportation Accidents

5.2.14.1 Facility Accidents. There has never been an accident in the history of the Naval

Nuclear Propulsion Program that resulted in a significant release of radioactivity to the environment or that resulted in radiation exposure to workers in excess of normal limits on exposure. Attachment F provides a description of radiological accidents which could occur during water pool and dry cell handling of naval spent nuclear fuel as well as accidents involving toxic chemicals used at ECF. The radiological accidents analyzed for ECF included: (1) an inadvertent criticality caused by an earthquake or similar event, (2) accidental loss of large amounts of water containing radioactive material from a water pool into the ground and then into water sources, and (3) severe damage of spent fuel if it were dropped from a crane during handling or had a heavy object dropped on it. The probability of an accident caused by an airplane crash was calculated for ECF and was determined to be less than 10-7. Due to the low probability, no consequences were calculated for this accident. Calculations of the cancer fatalities which might occur as a result of all the postulated accidents are provided in Attachment F. A comparison of the accident consequences for all alternatives is provided in Section 3.7.

The most limiting of the postulated accidents at ECF was water pool drainage, ultimately resulting in fuel overheating. The exposure to the entire population from this accident is calculated to cause 0.017 cancer fatalities over 50 years, as described in Attachment F.

The exposures to collocated workers following all accidents are well below the naval and DOE 5-rem standard for occupational exposure. However, exposures to the worker located at the ECF site 100 meters from the radiation release point would exceed this standard following an accident resulting in an inadvertent criticality.

Effects from accidents at ECF involving toxic chemicals were evaluated in Attachment F. Due to the amount and types of chemicals stored at ECF, toxic chemicals do not pose a risk to the public or the maximally exposed off-site individual following any of the postulated accidents. However, following the maximum foreseeable accident analyzed (a fire transient), a number of toxic chemicals would exceed Emergency Response Planning Guideline (ERPG) values for workers at ECF.

For maximum off-site individuals at INEL, ERPG-1 values for the toxic chemicals are not exceeded under 50% or 95% meteorology conditions. The concentrations of toxic chemicals following the fire transient as well as a summary of the analysis methods are provided in Attachment F.

5.2.14.2 Transportation Accidents. The health effects associated with accidents during

shipments of naval spent nuclear fuel and test specimens have been assessed for the general population and the hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any health effects as a result of naval spent nuclear fuel and test specimen shipments since the risk estimates are much less than one fatal cancer or detrimental health effect for each alternative. However, the most severe accident, with a likelihood of occurrence greater than 1 x 10-7 events per year, is estimated to result in a maximum of approximately 2 fatalities. The details of the transportation analysis are provided in Attachment A.

5.2.14.3 Other Impacts of Accidents. In addition to the possible human health effects

associated with facility or transportation accidents described in the preceding sections, other effects such as the impacts on socioeconomics and land use in the area and the costs of cleanup have been estimated in order to develop a perspective and to evaluate potential differences among alternatives.
The analyses described in Attachment F showed that for the most severe hypothetical accidents, an area of approximately 8 to 11 acres, extending about 1/4 to 1/3 mile downwind, might be contaminated to the point where exposure could exceed 100 millirem per year. Beyond this distance, exposures would be below 100 millirem per year, the Nuclear Regulatory Commission's standard for protection of the general population from radiation. Persons who work at the federal facilities within this area might be prevented from going to their jobs until measures had been taken to reduce the potential for exposure.

The area affected by the hypothetical accidents would not extend beyond the boundaries of the INEL and, in fact, would not come close to approaching the boundaries. An accident might result in short-term restrictions on access to a relatively small area of the federally owned site, but it would not be expected to produce enduring impacts on cultural or similar resources or concerns such as Native American rights or interests, partially because the area involved would be small and partly because all remedial actions would be conducted in a careful, controlled manner and in full compliance with applicable laws and regulations. The area would vary only slightly among the alternatives considered.
Overall, the risks are small so these considerations do not assist in distinguishing among alternatives.

Facility or transportation accidents associated with any of the alternatives would not have an appreciable effect on the ecology of the area, considering the potential for human health effects and the amount of land which might be affected, as described in earlier parts of this section. There is little consensus among scientists on methods for estimating the effects of radiation on ecological resources such as plant or animal life, but since human health effects for all the accidents analyzed are small and most plants and animals are not thought to be more sensitive to radiation than human beings, the small impacts on human health provide an indication that the impacts on animal and plant species in the area would also be small for all alternatives considered. Similarly, since the areas which might be contaminated by chemicals or radioactive material to measurable levels during the hypothetical accidents would be relatively small, any effects on the ecology would be limited to small areas. As previously stated, there are no endangered or threatened species unique to the area surrounding the Expended Core Facility at INEL, so an accident would not be expected to result in destruction of any species for any of the alternatives considered. The effects of accidents associated with any of the alternatives and any cleanup which might be performed would be localized within a small area extending only a short distance from the Expended Core Facility and thus would not be expected to appreciably affect the potential for survival of any species. Consequently, consideration of impacts of accidents on ecological resources does not help to distinguish among alternatives.

5.2.14.4 Effects of Accidents on Environmental Justice Due to Naval Spent Nuclear Fuel

Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from facility or transportation accidents associated with the management of naval spent nuclear fuel at the INEL would be small under any of the alternatives considered. For example, it is unlikely that a single additional fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to an accident for any of the alternatives considered would present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects from accidents associated with the management of naval spent nuclear fuel would be expected for any particular segment of the population, minorities and low-income groups included.

To place the impacts on environmental justice in perspective, the risk from hypothetical accidents associated with naval spent nuclear fuel examination under any of the alternatives considered would amount to less than one additional fatality per year in the entire population. For comparison, in 1990 there were approximately 40,000 traffic fatalities in the United States population and there were about 7,400 deaths caused by traffic accidents among people of color in the U. S. Even if all of the additional cancer deaths associated with an accident involving any of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would experience less than one additional fatal cancer per year. The same conclusion can be drawn for low-income groups.

5.2.15 Waste Management

All non-hazardous solid wastes that cannot be recycled or used by other government agencies are transported to the INEL landfills at the Central Facilities Area. Operation of ECF makes little contribution to these wastes other than the trash associated with the approximately 500 persons who work at that facility. Therefore, the impact in this area at the INEL is little affected by the alternative selected.

The use of hazardous materials in essential applications at ECF results in the generation of some hazardous wastes, including photographic solutions, solutions containing heavy metals, organic solvents, paint-related wastes, and laboratory wastes. All hazardous wastes are transported by vendors to treatment, storage, and disposal facilities approved by the Environmental Protection Agency and operating under approvals or permits granted by state and federal regulatory agencies, and none are disposed of at INEL. When appropriate, wastes are recycled or provided to other federal agencies for use. The small amount of hazardous waste produced from ECF operation would be produced and managed in the same manner if the facility were constructed and operated at an alternate site, so the overall effect on the environment, including that in the vicinity of INEL, is essentially unchanged by the alternative selected.

Operations at ECF contribute approximately 425 cubic meters (15,000 cubic feet) of radioactive solid waste each year and this amount of solid radioactive waste would be reduced by approximately 75% after about three years if an alternative which stopped naval spent nuclear fuel examinations at INEL were selected. No high-level waste and almost no transuranic waste (less than 0.0001 cubic meter per year) are generated from current operations at ECF. None of the alternatives considered would increase the amount of radioactive waste at INEL resulting from naval spent nuclear fuel examinations. The radioactive waste from ECF examinations and related operations would be generated and managed in a similar manner if the facility were constructed and operated at an alternative site. Consequently, the overall effect on the environment is essentially unchanged by the alternative selected.

5.2.16 Cumulative Impacts

Up to this point, Section 5.2 has discussed the potential environmental consequences of operation of the ECF Project at INEL in terms of annual impacts (i.e., radiological exposures and health effects, accident risks, and quantities of wastes that would be generated during operation) based on the maximum annual capacity of the ECF Project. To determine the upper limit for the potential consequences of up to 40 years of future ECF operation (from 1995 to 2035), an evaluation of the accumulated environmental consequences and risks of operating ECF was performed.

5.2.16.1 Radiological Cumulative Impacts. Operation of the INEL-ECF does not result in

discharges of radioactive liquids; therefore, there would be no changes to the surface or ground water as a result of normal operations for any alternative. There are small quantities of radioactivity in the air released from ECF which would contribute to the cumulative air quality impacts. For those alternatives where the ECF is shut down, the cumulative impacts would decrease by the amount of ECF radioactivity releases.

The radiation exposure to the general population since the beginning of operations associated with naval spent nuclear fuel is less than 2 rem, which corresponds to approximately 0.001 cancer fatality. An overview of the historical radiological impacts from naval nuclear operations at the INEL and from transportation of naval spent nuclear fuel is provided in Section 4.2.12 and detailed analyses are provided in Attachments F and A. Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

The annual radiological impacts associated with the alternatives where naval spent nuclear fuel would be inspected or stored at the ECF at INEL are very small and are described in Section 5.2.12, with the detailed results of analyses provided in Attachment F. In order to calculate cumulative impacts for the period between 1995 and 2035, the annual radiological impacts associated with each location and alternative were summed over 40 years. The results of this summation are tabulated in Tables 3-5 and 3-6 of Section 3.

The cumulative transportation impacts for the population groups from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated and are very small. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A and summarized in Section 3.7.4.

The total exposure to the general public from transportation and from the alternatives considered involving continued operation of the ECF at INEL would be less than 3.5 person-rem. This means that there would be less than 0.0017 fatal cancers from these operations over the entire 40-year period evaluated. The exposure to the maximally exposed off-site individual is calculated to be approximately 0.01 millirem from 40 years of ECF operation. The corresponding risk of a cancer fatality to the maximally exposed off-site individual is 5.2 x 10-9 during his or her lifetime. A worker at the ECF site located 100 meters from the facility would receive less than 3 millirem over 40 years of ECF operation, which corresponds to a 1.1 x 10-6 risk of fatal cancer during the worker's lifetime. Analyses of hypothetical accidents which might occur as a result of these alternatives show that the risk of cancer fatalities is small. The impacts associated with transportation of naval spent nuclear fuel for all of the alternatives considered would be similarly low.

Cumulative impacts due to radioactive waste generation are expected to be minimal.

Approximately 425 cubic meters of low-level waste are expected to be generated annually by ECF over the next 40 years. This is not expected to affect the INEL waste management program. Very little transuranic and mixed wastes and no high-level waste are generated from ECF operations.

No contribution to cumulative impacts from accidents involving naval spent nuclear fuel has been included in the analyses presented in this Environmental Impact Statement because there has never been a nuclear reactor accident, criticality accident, transportation accident, or any release of radioactivity which had a significant effect on the environment.

5.2.16.2 Non-radiological Cumulative Impacts. Cumulative socioeconomic impacts associated

with continued operation of the ECF Project at the INEL are expected to be minor. The INEL currently employs approximately 11,000 people. The ECF operations work force of 500 people would continue to be employed over the long term at INEL if an alternative is selected which would continue naval spent nuclear fuel examination at INEL. If an alternative were selected which resulted in naval fuel no longer being examined at INEL, the reduction in ECF work force would increase the predicted future reductions in work force at INEL by 500 jobs. Considering that the labor force in the region of influence consists of almost 105,000 people, the 500 ECF jobs would be expected to have only a minor impact in the INEL area.

Continued operation of the ECF Project at INEL is not expected to result in any appreciable impacts relative to cumulative non-radiological emissions. Current operations at INEL are in compliance with Title 40, Code of Federal Regulations, Part 61, "National Emission Standards for Hazardous Air Pollutants." Cumulative air emissions would not threaten to exceed any applicable air quality requirement or regulation, either federal, state, or local in radiological and non-radiological categories.

As discussed in Section 5.2.8, the withdrawal of groundwater for continued ECF operation would be a small percentage of existing water withdrawals at INEL and well within the cumulative capabilities of the local water resources. ECF discharges of non-radioactive and non-hazardous liquid effluents at INEL would not affect water quality. The volume of ECF routine liquid effluents discharged at INEL would also not discernibly increase the impact to the local ecology.

Operation of the ECF has no effect on cumulative land use impacts. NRF occupies less than 0.02% of the approximately 571,000-acre INEL site and no additional land would be disturbed. Even for the options in which ECF is shut down, there would be no cumulative land use impacts since the site would need to be decommissioned and decontaminated before releasing it for other uses and this work would extend beyond the time frame of this study.

The cumulative impacts associated with non-radiological waste management are also small. The volume of hazardous, municipal, and sanitary wastes produced by ECF has not been calculated; however, considering the nature of the work associated with ECF and the number of workers, the amount of hazardous, municipal, and sanitary waste produced has a small effect on the cumulative impacts associated with this waste. For those options in which ECF is shut down, the effect of these wastes on the cumulative impacts is even smaller.

5.2.17 Unavoidable Adverse Effects

Small amounts of radioactivity, described in Section 5.2.12, would be released as a result of spent fuel operations at ECF, resulting in less than one health effect in the entire population surrounding INEL. The effects of these small releases, combined with the other factors described in Section 5.2.16, would produce no discernible cumulative effects. Similarly, continued operation of the facility would produce limited amounts of liquid sanitary waste and solid municipal waste and solid low-level radioactive waste. These amounts of waste would not differ from those produced in the past by operation of ECF and would not produce any major impacts in the vicinity of INEL.

The most important adverse effect in the vicinity of INEL would be the loss of jobs which would occur if an alternative which shut down the Expended Core Facility were chosen. As discussed in Section 5.2.3 above, approximately 500 people at INEL would lose their jobs if such an alternative were selected.

5.2.18 Irreversible and Irretrievable Commitments of Resources

There are few irreversible or irretrievable commitments of resources, other than costs, at INEL associated with the selection of any of the alternatives considered for naval spent nuclear fuel. The total cost of operating the INEL-ECF is approximately $2.6 billion. This cost represents the total cumulative cost over the 40-year period and includes the operations costs for ECF as well as the construction costs for completing the Dry Cell Facility. Refer to Section 3.7 for a comparison of the total cumulative costs among alternatives.

In the event an alternative which resulted in ceasing operations at the Expended Core Facility were selected, decommissioning and decontamination of ECF would not occur immediately. Instead, the facility would be placed in a safe storage condition while the federal government decided on the proper disposition of the facility, planned the disposition, and programmed funds to carry out the disposition. Any disposition of the facility would be conducted in accordance with applicable federal and state regulations.

5.3 SAVANNAH RIVER SITE

5.3.1 Overview of Environmental Impacts

The following sections discuss the potential environmental consequences that would occur if a replacement for the Expended Core Facility (ECF) were constructed and operated at the Department of Energy's Savannah River Site (SRS) or if the Barnwell Nuclear Fuel Plant (hereafter referred to as the Barnwell Plant) that is adjacent to and contiguous with the SRS were operated for this purpose. Both of these subalternatives will be referred to as the Savannah River ECF. The two proposed sites are depicted as Site A and Site B in Figure 4.3-1. Details of receipt, handling, and examination of naval spent nuclear fuel at the SRS and the modifications to the Barnwell Plant are described in Attachment E.

The environmental consequences of locating the ECF at the SRS are based on the same radiological source terms for normal and accidental releases and the estimated ECF atmospheric emissions, liquid effluents, and solid wastes discussed in Section 5.2. Consistent with the scope of a programmatic Environmental Impact Statement, the environmental effects due to normal and accidental releases were evaluated primarily for Site A. Some variations in the exposure to off-site individuals and workers at other SRS facilities would occur for the Barnwell Plant site. The environmental consequences of locating and operating the ECF at SRS would be similar to those for the ECF at the Idaho National Engineering Laboratory (INEL), and none would be large.

5.3.2 Land Use

Construction of a Savannah River ECF Project at Site A would directly affect about 30 acres of land. The Savannah River ECF site considered and its adjacent environs are relatively diverse and contain both pine stands and mixtures of hardwoods. Construction would not disturb any critical or sensitive ecological habitats, nor would it impact wetland areas. Compared to the INEL-ECF site, however, the Savannah River ECF site is considered more ecologically diverse.

The alternative location at the Barnwell Plant is approximately 6 miles from the Site A location. Forest removal at this site has already been completed, and any additional construction is not expected to have any effect on land use.

Native American rights and interests would not be modified by construction or operations associated with any of the alternatives considered.

5.3.3 Socioeconomics

The potential socioeconomic impacts associated with construction of the Savannah River ECF are expected to be equal to or less than those associated with the original ECF construction at the INEL because (1) a large movement of construction workers from other areas would not be expected for the Savannah River ECF construction due to the availability of construction craft workers within 70 miles of the SRS (Halliburton 1992); and (2) the six counties surrounding the SRS have a population much larger than the INEL area, which would provide a greater capability to absorb any temporary relocation of construction personnel.

Table 5.3-1 provides a summary of the direct jobs which would be required for the construction and operation of the Savannah River ECF during the 10-year period immediately after the Record of Decision. The greatest number of direct jobs would occur in 1999 during the peak of the construction phase. Estimates of the indirect jobs created as well as the effect on area population are included in Section 5.5.3 of Volume 1 as part of either the Regionalization or Centralization at the SRS alternatives.

Table 5.3-1. Summary of direct jobs due to the Savannah River ECF.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Direct Jobs	20	20	476	825	1033	894	850	500	500	500

During the Savannah River ECF construction period, operations personnel would be hired so that at the end of the construction period, most of the operations workers would be employed. When fully staffed, ECF operation at the SRS would require approximately 500 people, the same number of operating and support personnel as at the INEL-ECF. This would represent less than 3 percent of the total SRS work force. The six-county region of influence around the SRS had a 1990 population of 425,607 persons, or about twice that of the INEL. The larger population base associated with the SRS region would also provide a greater capability to absorb any personnel moving into the area during the construction period; however, the larger economic base of the SRS region (DOE 1988) would also have a greater tendency to diffuse potential economic benefits compared to the ECF Project at the INEL.

Given the small percentage increase in the number of jobs at the SRS attributable to Savannah River ECF operation, the impacts to local government services and community infrastructures are expected to be small. Volume 1 quantifies these effects. The economic benefits to the SRS region are expected to be similar to or less than those for the INEL region as the existing economic base of the SRS region is much greater and more diverse than the INEL region (DOE 1988).

5.3.4 Cultural Resources

None of the alternatives considered would impact known historical, archaeological or Native American sites. Procedures which comply with all applicable laws and regulations would be implemented to protect previously undetected archaeological and cultural sites.

5.3.5 Aesthetic and Scenic Resources

The construction of the Savannah River ECF at Site A would directly affect 30 acres of land. As a result of its location and industrial characteristics, there is essentially no aesthetic or scenic impact, since the site would not be visible to the public.

No additional land would need to be cleared if the Barnwell Plant were used for an ECF. The building containing the existing water pool would need to be enlarged as part of the modifications discussed in Attachment E; however, the effect on the scenic resources would be minimal.

5.3.6 Geology

5.3.6.1 General Geology. The local geology of the SRS region determines the locations of the

surface waters and groundwaters at the site described in "Reactor Operation Environmental Information Document, Volume I, Geology, Seismology and Subsurface Hydrology" (WSRC 1989). The geology of the SRS region has not been affected by operations conducted at SRS and is not expected to be affected by Savannah River ECF operations.

5.3.6.2 Geologic Resources. The geology of both sites considered has sufficient strength to

support construction of the ECF structures, and operation of the Savannah River ECF is not expected to affect any geologic resources.

5.3.7 Air Resources

Toxic chemicals are used in the normal operations of an ECF. The use of these chemicals is controlled to limit the exposure of workers and the public. Airborne emissions from normal operations include the combustion gases from the boiler house, where fuel oil is burned to make steam from space heating. Emergency diesel generators, which are provided for safety, are operated periodically for test purposes and release exhaust fumes to the atmosphere. These emissions would not have any detectable environmental consequence.

The airborne releases of radioactivity for the Savannah River ECF would be the same as the INEL-ECF described in Section 5.2. The airborne release would result in no measurable exposure to on-site personnel or the general population. Details are provided in Attachment F.

5.3.8 Water Resources

5.3.8.1 Surface Water. Water required for construction of the facility would be withdrawn from

the Savannah River. The small amount of water withdrawn from the Savannah River would be negligible in comparison to the approximately 4.5 million gallons-per-minute flow near the SRS. No new water intake structure would be required.

Expected surface water withdrawals of 2.5 million gallons per year from the Savannah River during Savannah River ECF operations represent small incremental increases in the amount of water currently being withdrawn by on-going SRS operations (23.2 billion gallons annually) and represent a negligible withdrawal in comparison to the average flow of the Savannah River. There would be no discharge of Savannah River ECF liquids to the Savannah River.

5.3.8.2 Groundwater. Sanitary effluents generated during construction would be treated through

either the use of chemical toilets or a wastewater treatment facility. Solid waste generated during construction would be disposed of in the SRS sanitary landfill, which is operated in accordance with State of South Carolina guidelines. Mitigation and control measures for potential spills, fugitive dust, and erosion would be undertaken as part of construction activities.

Sanitary effluents generated as a result of Savannah River ECF operations would be discharged to a wastewater treatment plant. There would be no discharge of radioactive or hazardous liquid effluents to the ground at the Savannah River ECF site. Construction and operation of the Savannah River ECF is not expected to have an effect on the groundwater.

5.3.9 Ecological Resources

5.3.9.1 Terrestrial Ecology. During construction, plant and animal habitats associated with pine

and hardwood vegetation communities would be lost or displaced from the construction site. Additionally, construction may have short-term impacts on wildlife beyond the immediate construction site (i.e., impact on area animals due to construction and traffic noise). However, because the affected land area is small compared to the entire SRS, the impacts on wildlife from construction are expected to be minor.

During construction and operation of the Savannah River ECF, all effluents and emissions would comply with regulatory standards. Due to the level of the emissions described in Attachment F, they are not expected to have an impact on the area wildlife. Operation of the Savannah River ECF should result in less noise and traffic than the construction phase, and no effects on terrestrial ecology are expected from Savannah River ECF operation.

5.3.9.2 Wetlands. The only wetlands located on the proposed Savannah River ECF sites are the

Carolina Bays located at Site A. Because the Carolina Bays are located on the edge of the proposed site, they can be avoided during construction. Construction and operation of the Savannah River ECF would have no discernible impacts on other wetland areas and habitats at the SRS.

5.3.9.3 Aquatic Ecology. Experience has shown that SRS operations (e.g., reactor operation) can

have an adverse effect on the receiving aquatic ecosystems (e.g., L-Lake, Steel Creek, Pen Branch, etc.). However, because there would be no discharge of radioactive or hazardous liquid effluents from Savannah River ECF operation, Savannah River ECF operation is expected to have no effect on the aquatic ecology.

5.3.9.4 Endangered and Threatened Species. The endangered and threatened species are

described in Volume 1, Appendix C. The construction and operation of the Savannah River ECF are not expected to have any environmental impact on the endangered and threatened species found at the SRS.

5.3.10 Noise

The SRS is a large area of about 800 square kilometers (310 square miles). If the alternative involving construction of a new facility were selected, the construction of the Savannah River ECF would cause typical construction noises. There would be little or no noise accompanying normal operations of the Savannah River ECF.

5.3.11 Traffic and Transportation

Traffic and transportation would increase slightly in the SRS area if an ECF is constructed and operated at the SRS. The additional traffic would mainly be due to increased commuter traffic from construction workers and 500 operations workers as well as traffic from material shipments during the Savannah River ECF construction.

If the ECF Project were located at the SRS, routine shipments of naval spent nuclear fuel would be transported to the site in certified shipping containers. Low-level waste generated at the facility and transuranic waste would be moved from the facility to an SRS storage facility.

5.3.12 Occupational and Public Health and Safety

The health and safety assessment of normal operations at the Savannah River ECF was based on managing spent nuclear fuel for examination and storage by either of two approaches (i.e., handling in a water pool or in a dry cell). These are the same methods of spent nuclear fuel handling that have been employed or seriously considered for use at the INEL-ECF. The normal operational impacts associated with the Savannah River ECF would be similar to those for the INEL-ECF. The following sections describe the non-radiological and radiological impacts associated with the Savannah River ECF (refer to Section 5.2 for the INEL-ECF impacts).

5.3.12.1 Occupational Health and Safety. Projections of the number of occupational accidents

that might occur during construction and operation of naval spent nuclear fuel storage and examination facilities have been made for each alternative. These projections are presented in Attachment F. Based on the results of these projections, it is concluded that the number of occupational fatalities and injuries or illnesses for construction activities and storage and examination operations would be very small for any alternative.

During Savannah River ECF construction, workers are not expected to experience elevated background levels of radiation resulting from on-going SRS operations. The gamma radiation measured near the proposed Savannah River ECF site is similar to the radiation levels measured off-site in the SRS area (WSRC 1992). The potential exposure to a construction worker from inhalation of radionuclides released to the atmosphere from existing SRS operations is estimated to be less than 1 millirem per year, which is small compared to the external exposure. The very small exposure received by a construction worker would be well below the naval and Department of Energy (DOE) standard of 5000 millirem per year for occupationally related whole-body and internal exposures.

During operation of the Savannah River ECF, SRS personnel would be exposed to routine atmospheric emissions of radioactivity and might be exposed to potential emissions from accidents. Site A is located approximately 1 mile from the nearest SRS facility, while the Barnwell Plant is located approximately 5 miles from the nearest facility. As shown in Attachment F, no measurable exposure would be received by these collocated workers from normal Savannah River ECF operations. Exposures received by Savannah River ECF radiation workers from normal operations are expected to be similar to the exposures currently received by workers from ECF operation at the INEL, discussed in Section 5.2.12.

5.3.12.2 Public Health and Safety. The impacts of normal operation of the Savannah River ECF

would be similar to those for the INEL-ECF. Normal radiological releases to the atmosphere and the quantities of radioactive and hazardous wastes that would be generated would not differ from those previously discussed for the INEL. However, the location of the project relative to the surrounding SRS population and the distances to facilities that would be involved in routine shipments of material would result in differences in potential environmental consequences. Described below are the impacts to the public associated with operation of the Savannah River ECF (refer to Section 5.2.12 for the INEL-ECF impacts).

Assessment of the normal operations of the Savannah River ECF involved two options: fuel handling in a water pool and dry cell handling of fuel for examination and storage. For both options considered, the potential annual exposures were estimated for five different types of people: a worker at the Savannah River ECF site located 100 meters from the release point, the hypothetical maximally exposed collocated worker on the SRS site, the hypothetical maximally exposed off-site individual (MOI), an individual at the nearest public access (NPA), and the population within 80 kilometers (50 miles) of the Savannah River ECF site. Three pathways were included in the analysis: airborne, waterborne, and direct radiation, as applicable.

The results indicate that either the water pool or the dry cell option would be satisfactory for normal operations since the exposure is so low. The analysis shows that the exposure to all the individuals considered (workers, collocated workers, MOI, and NPA) from Savannah River ECF operations would be much less than 1 millirem per year. For perspective, it could be stated that one member of the entire population might experience a fatal cancer due to Savannah River ECF operations if operations continued for over 50,000 years. A description of the analysis methods and more detailed results are provided in Attachment F. The impacts from normal operations for all alternatives are summarized in Section 3.7.

The radiological and non-radiological health effects associated with the incident-free transportation of naval spent nuclear fuel and test specimens have been assessed for the general population, transportation workers, and hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancers as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. The details of the transportation analysis are provided in Attachment A.

5.3.12.3 Incident-free Occupational and Public Health and Safety Effects on Environ-

mental Justice Due to Naval Spent Nuclear Fuel Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from normal operations associated with the examination of naval spent nuclear fuel at the SRS would be small under any of the alternatives considered. For example, it is unlikely that a single fatal cancer would occur as a result of activities associated with naval spent nuclear fuel examination under any alternative. Since the potential impacts due to normal operations or accident conditions for any of the alternatives considered present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is true for normal operations because the effects of routine operations are so small. It is also true for accident conditions because the consequences of any accident would depend on the random conditions at the time it occurred, and the wind directions at the SRS do not display any strongly dominant direction. Similarly, the conclusion is not affected by concerns related to subsistence consumption of fish or game because of the very small impacts associated with examination of naval spent nuclear fuel.

To place the impacts on environmental justice in perspective, the risk associated with routine operations for naval spent nuclear fuel examination under any of the alternatives considered would be less than one fatality per year for the entire population. For comparison, in 1990 there were approximately 510,000 cancer deaths in the United States population and there were about 64,000 cancer deaths among people of color in the U. S. Even if all of the impacts associated with one of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would be unlikely to experience a single additional cancer fatality in any year. Therefore, the cancer risk for that population from naval spent nuclear fuel management would not constitute a disproportionately high and adverse impact on human health or the environment. The same conclusion can be drawn for low-income groups.

5.3.13 Utilities and Energy

Heating, ventilation, and electrical systems appropriate to the needs of the Savannah River ECF for suitable working environments and to properly filter and exhaust the airborne discharges to the atmosphere are estimated to require approximately 10,000 MWh per year for normal operations. Emergency diesel electrical generators would provide 350 kw for life support and crucial facility services during power outages. The amount of energy consumed would be a small fraction of the total energy used at SRS, and no discernible environmental consequence is expected.

5.3.14 Facility and Transportation Accidents

The differences in the potential consequences and risks of accidents of a Savannah River ECF compared to the INEL-ECF are related to the meteorological transport of released material, the population exposure, and the distance of transport. The following sections address the potential accident consequences and risks associated with locating an ECF at the SRS.

5.3.14.1 Facility Accidents. The accident scenarios for the Savannah River ECF are the same as

those considered for the existing ECF at the INEL. These include radiological accidents which could occur during water pool and dry handling of spent nuclear fuel as well as accidents involving toxic chemicals used at ECF. The general types of radiological accidents analyzed included: (1) accidental criticality, (2) water pool drainage, (3) severe mechanical damage of spent fuel, (4) partial loss of shielding, and (5) an airplane crash into the ECF. Calculations of the cancer fatalities which might occur as a result of all the postulated accidents are provided in Attachment F. A comparison of the accident consequences for all alternatives is provided in Section 3.7.

The difference in the calculated consequences for accidents at the Savannah River ECF compared to the INEL-ECF is that the exposure received by the entire population would be greater at the Savannah River ECF due to the larger population within an 80-kilometer (50-mile) radius of the Savannah River ECF project site. Although the exposure received would be greater at the Savannah River ECF, the number of health effects which would result from any of the accidents considered would be small. The most limiting of the postulated accidents for the Savannah River ECF was an airplane crash into a dry cell facility. If this accident were to occur, the exposure to the entire population from this accident is calculated to cause 4.8 cancer fatalities over 50 years, as described in Attachment F. The risk associated with the airplane crash is 0.0000096 fatal cancers per year.

The exposures to collocated workers following all accidents are below the naval and DOE 5-rem standard for occupational exposure under 50% meteorology conditions. However, exposures to the worker located at the Savannah River ECF site 100 meters from the radiation release point would exceed this standard following an accident resulting in an inadvertent criticality and following an airplane crash.

Effects from accidents at the Savannah River ECF involving toxic chemicals are similar to those described in Section 5.2.14 for the existing INEL-ECF. Due to the amount and types of chemicals stored at the ECF site, toxic chemicals do not pose a risk to the public following any of the postulated accidents. However, following the maximum foreseeable accident analyzed (a fire transient), a number of toxic chemicals would exceed Emergency Response Planning Guideline (ERPG) values for workers on the Savannah River ECF site as well as for collocated workers. For the MOI under either 50% or 95% meteorology conditions, toxic chemical levels do not exceed ERPG-2 values with the ECF at Site A and ERPG-3 values if the ECF is at the Barnwell Plant Site. The concentrations of toxic chemicals as well as a summary of the analysis methods are provided in Attachment F.

5.3.14.2 Transportation Accidents. The health effects associated with accidents during

shipments of naval spent nuclear fuel and test specimens have been assessed for the general population and hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any health effects as a result of naval spent nuclear fuel and test specimen shipments since the risk estimates are much less than one fatal cancer or health effect for each alternative. However, the most severe accident, with a likelihood of occurrence greater than 1 x 10-7 events per year, is estimated to result in a maximum of approximately 2 fatalities. The details of the transportation analysis are provided in Attachment A.

5.3.14.3 Other Impacts of Accidents. In addition to the possible human health effects

associated with facility or transportation accidents described in the preceding sections, other effects such as the impacts on socioeconomics and land use in the area and the costs of cleanup have been estimated in order to develop a perspective and to evaluate potential differences among alternatives. The analyses described in Attachment F showed that for the most severe hypothetical accidents, an area of between about 8 acres extending about 1/4 mile downwind (for an accidental criticality) and approximately 210 acres extending about 1 1/4 mile downwind (for a large airplane crash into the fuel examination facility) might be contaminated to the point where exposure could approach 100 millirem per year. Beyond these distances, exposure would be less than 100 millirem per year, the Nuclear Regulatory Commission's standard for protection of the general population from radiation. The area affected by the hypothetical facility accidents would not extend beyond the boundaries of the Savannah River Site. However, if the currently inactive Barnwell Nuclear Fuel Plant were the site of such an accident, the affected area could extend beyond the boundaries of federally owned property. Persons who live in this area might be evacuated or otherwise experience restrictions in their daily activities for a brief period, and those who work at locations within this area might be prevented from going to their jobs until measures had been taken to reduce the potential for exposure.

An accident might result in short-term restrictions on access to a relatively small area, but there would be no enduring impacts on cultural or similar resources or concerns such as Native American rights or interests, partially because the area involved would be small and partly because all remedial actions would be conducted in a careful, controlled manner in full compliance with applicable laws and regulations. The area impacted would vary only slightly among the alternatives. Overall, the risks are small so these considerations do not assist in distinguishing among alternatives.

Facility or transportation accidents associated with an Expended Core Facility at the Savannah River Site would not have an appreciable effect on the ecology of the area, considering the potential for human health effects and the amount of land which might be affected, as described in earlier parts of this section. There is little consensus among scientists on methods for estimating the effects of radiation on ecological resources such as plant or animal life, but since human health effects for all the accidents analyzed are small and most plants and animals are not thought to be more sensitive to radiation than human beings, the small impacts on human health provide an indication that the impacts on animal and plant species in the area would also be small for an alternative which would relocate the Expended Core Facility to the Savannah River Site. Similarly, since the areas which might be contaminated to measurable levels by chemicals or radioactive material during the hypothetical accidents would be relatively small, any effects on the ecology would be limited to small areas. As previously stated, there are no endangered or threatened species unique to the area surrounding the location considered for a replacement Expended Core Facility at the Savannah River Site, so an accident would not be expected to result in destruction of any species. The effects of accidents associated with these alternatives or any cleanup which might be performed would be localized in a small area extending only a relatively short distance from the Expended Core Facility and thus would not be expected to appreciably affect the potential for survival of any endangered or threatened species in the Savannah River area. Consequently, consideration of impacts of accidents does not help to distinguish among alternatives.

5.3.14.4 Effects of Accidents on Environmental Justice Due to Naval Spent Nuclear Fuel

Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from facility or transportation accidents associated with the management of naval spent nuclear fuel at the SRS would be small under any of the alternatives considered. For example, it is unlikely that a single additional fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to an accident for any of the alternatives considered would present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects from accidents associated with the management of naval spent nuclear fuel would be expected for any particular segment of the population, minorities and low-income groups included.

To place the impacts on environmental justice in perspective, the risk from hypothetical accidents associated with naval spent nuclear fuel examination under any of the alternatives considered would amount to less than one additional fatality per year in the entire population. For comparison, in 1990 there were approximately 40,000 traffic fatalities in the United States population and there were about 7,400 deaths caused by traffic accidents among people of color in the U. S. Even if all of the additional cancer deaths associated with an accident involving any of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would experience less than one additional fatal cancer per year. The same conclusion can be drawn for low-income groups.

5.3.15 Waste Management

During Savannah River ECF operation, non-radioactive and non-hazardous solid waste and hazardous solid waste would be generated in quantities similar to those for the INEL-ECF. Non-radioactive, non-hazardous wastes would be managed in a manner identical to that for the INEL-ECF (i.e., non-hazardous, non-radioactive solid wastes would be disposed of at a sanitary landfill). Hazardous wastes would be contained at their point of generation and stored at the SRS. Waste management practices for these wastes would produce no identifiable impact on public health and safety of the environment.

Operation of the ECF at the SRS would generate the same quantities of low-level waste, transuranic waste, and mixed wastes as the INEL-ECF. Low-level waste generated by the Savannah River ECF would be stored at the SRS. The 425 cubic meters of low-level waste generated annually by the ECF Project represents a small quantity when compared to the quantity of low-level waste disposed of at the SRS and would not impact planned disposal operations. No high-level waste would be generated.

Less than 0.0001 cubic meter of transuranic waste per year is generated by current ECF operations at the INEL. Any transuranic waste generated by the Savannah River ECF would be in addition to approximately 10,000 cubic meters currently held in storage at the SRS. Transuranic wastes generated at the Savannah River ECF would be a very small fraction of the SRS transuranic waste generated and would not impact planned SRS waste-handling operations.

Mixed wastes generated by Savannah River ECF operation would be stored at the SRS until treatment and disposal facilities are available. The amount of mixed waste generated would represent a small quantity in relation to the quantities requiring storage or disposal from past and ongoing SRS operations.

5.3.16 Cumulative Impacts

Up to this point, Section 5.3 has discussed the potential environmental consequences of constructing and operating the ECF Project at the SRS in terms of annual impacts (i.e., radiological doses and health effects, accident risks, and quantities of wastes that would be generated during operation) based on the maximum expected annual throughput of the ECF Project. To determine the potential consequences for 40 years of ECF operation (from 1995 to 2035), an evaluation of the accumulated environmental consequences and risks of constructing and operating the Savannah River ECF was performed.

5.3.16.1 Radiological Cumulative Impacts. The Savannah River Site has not been used for

naval spent nuclear fuel operations in the past. Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

Operation of the Savannah River ECF will not result in discharges of radioactive liquids;

therefore, there would be no changes to the surface or ground water as a result of normal operations for any alternative. There will be small quantities of radioactivity in the air released from ECF which would contribute to the cumulative air quality impacts.

The annual radiological impacts associated with the alternatives where naval spent nuclear fuel would be inspected or stored at SRS are very small and are described in Section 5.3.12, with the detailed results of analyses provided in Attachment F. In order to calculate cumulative impacts for the period between 1995 and 2035, the annual radiological impacts associated with each location and alternative were summed over 40 years. The results of this summation are tabulated in Tables 3-5 and 3-6 of Section 3.

The cumulative transportation impacts for the population groups from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated and are very small. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A and summarized in Section

3.7.4.

The total exposure to the general public from transportation and from Savannah River ECF operations would be less than 14 person-rem. This means that there would be less than 0.0067 fatal cancers from these operations over the entire 40-year period evaluated. The exposure to the maximally exposed off-site individual would be less than 0.2 millirem from 40 years of Savannah River ECF operation at either Site A or the Barnwell Plant. The corresponding risk of a cancer fatality to the maximally exposed off-site individual is 9.6 x 10-9 at Site A and 7.6 x 10-8 at the Barnwell Plant during his or her lifetime. A worker at the Savannah River ECF site located 100 meters from the facility would receive less than 4 millirem over 40 years of Savannah River ECF operation, which corresponds to a 1.4 x 10-6 risk of fatal cancer during the worker's lifetime. These exposures and cancer risks are as a result of ECF operations only. The exposures and risks corresponding to site-wide operations (including ECF) are discussed in Volume 1, Chapter 5. Analyses of hypothetical accidents which might occur as a result of these alternatives show that the risk of cancer fatalities is small. The impacts associated with transportation of naval spent nuclear fuel for all of the alternatives considered would be similarly low.

Cumulative impacts due to radioactive waste generation are expected to be minimal. Approximately 425 cubic meters of low-level waste are expected to be generated annually by the Savannah River ECF over the next 40 years. This is not expected to affect the SRS waste management program. Very little transuranic waste or mixed waste and no high-level waste will be generated from Savannah River ECF operations.

No contribution to cumulative impacts from accidents involving naval spent nuclear fuel has been included in the analyses presented in this Environmental Impact Statement because there has never been a nuclear reactor accident, criticality accident, transportation accident, or any release of radioactivity which had a significant effect on the environment.

5.3.16.2 Non-radiological Cumulative Impacts. Cumulative socioeconomic impacts associated

with constructing and operating the ECF Project at the SRS are expected to be minor. The SRS currently employs over 20,000 people. In the past, no employment at the SRS has been associated with naval spent nuclear fuel operations. Savannah River ECF operations would provide long-term employment for 500 people at the SRS and would help offset predicted future reductions in the SRS work force (Halliburton 1992). The peak number of additional jobs created at the SRS in any given year would be approximately 1050, which includes both construction and operations workers during the peak of the Savannah River ECF construction effort. Considering that the labor force in the region of influence consists of 209,000 people, the additional number of jobs added from the construction and operation of the Savannah River ECF would be expected to have only a minor socioeconomic impact in the SRS area.

Construction and operation of the ECF Project at the SRS are not expected to result in any discernible impacts relative to cumulative non-radiological emissions. Construction of the ECF Project at either Site A or Site B is sufficiently remote and removed from the nearest SRS boundaries such that concentrations of fugitive emissions from construction would be well below applicable standards, as discussed in Section F.4 of Attachment F. Current operations at the SRS are in compliance with Title 40, Code of Federal Regulations, Part 61, "National Emission Standards for Hazardous Air Pollutants." Cumulative air emissions would not threaten to exceed any applicable air quality requirement or regulation, either federal, state, or local in radiological and non-radiological categories.

As discussed in Section 5.3.8, the withdrawal of surface water for ECF construction and operation at the SRS would be a small percentage of existing withdrawals and well within the cumulative capabilities of the respective water resources. ECF discharges of non-radioactive and non-hazardous liquid effluents at the SRS would not affect water quality. The volume of ECF routine liquid effluents discharged at SRS would also have no measurable impact on aquatic biota or the wetland habitat.

Minimal cumulative land use impacts would be expected to occur as a result of the construction of a new ECF. The land that would be dedicated for this purpose is on existing federal property. The use of this land would not result in the need for additional land to be added to the federally owned property in the foreseeable future. The SRS occupies an area of approximately 800 square kilometers (310 square miles) with only about 5% of the land occupied by constructed facilities. No land area at the Savannah River Site has been affected by past operations involving naval spent nuclear fuel. Construction of the Savannah River ECF would affect 30 acres of land. This is less than 0.02% of the total Savannah River Site land area.

The cumulative impacts associated with non-radiological waste management are also expected to be small. The volume of hazardous waste produced by ECF has not been calculated; however, considering the nature of the work associated with ECF, the amount of hazardous waste produced would have a small effect on the cumulative impacts associated with this waste. The volume of municipal solid wastes and sanitary wastes which would be generated is expected to be proportional to the number of additional workers added, and this small incremental increase would not be discernible. The amount of non-radiological wastes generated would not introduce any changes to the site's waste management practices and would not impose any additional stress on the capacity of on-site or off-site waste disposal or treatment facilities. Therefore, any cumulative impacts associated with the generation and disposal of additional wastes would be very small. There are no current environmental problems associated with these types of wastes.

5.3.17 Unavoidable Adverse Effects

The construction of the ECF Project at the SRS would directly impact about 30 acres of land area. An estimated 30 acres of stands of loblolly pine and mixtures of hardwoods would be cleared as part of construction activities for Site A. For the Barnwell Plant, no land would need to be cleared due to the limited amount of construction required for this site. During construction at Site A, plant and animal habitats associated with pine and hardwood vegetation communities would be lost or displaced.

Construction of the Savannah River ECF would also generate liquid effluents, atmospheric emissions, and solid wastes typical of those for construction of a major industrial facility. All effluents and emissions would be below applicable environmental requirements and would not be expected to result in any major adverse impacts.

During Savannah River ECF operation, non-radioactive and non-hazardous solid waste and hazardous solid waste would be generated in quantities similar to those discussed for the INEL. Non-radioactive and non-hazardous solid waste would be disposed of in the SRS sanitary landfill and off-site in a commercial landfill. Hazardous wastes would be stored at the SRS in storage buildings or on storage pads. The Resource Conservation and Recovery Act regulates these wastes. The amount of hazardous waste generated by Savannah River ECF operation would be small in comparison to the amount of hazardous waste that is generated and currently in interim storage at the SRS. No discernible differences from normal hazardous waste management at the SRS would result from this strategy.

During Savannah River ECF operation, unavoidable radiation exposures would include occupational exposures and exposures to the public from normal atmospheric emissions of radioactive materials that would be minimal compared to criteria contained in the Environmental Protection Agency's 40CFR61 and DOE Order 5480.1B. Sanitary waste and service waste liquid discharges would be below applicable environmental standards. Solid wastes generated during operation, including transuranic, low-level, hazardous, and mixed wastes, would result in small increases in potential exposures to radioactive and hazardous materials. Freon emissions would result in a negligible increase in the risk of skin cancer; substitutes will be used when available.

In general, the unavoidable adverse impacts would be few and limited, and none have been identified that would have a detectable effect on public health and safety. The difference in the impacts between the ECF alternative at SRS and the other DOE sites (INEL, Hanford, Oak Ridge, Nevada Test Site) is not discernible.

5.3.18 Irreversible and Irretrievable Commitments of Resources

During operation of the Savannah River ECF, additional fuel oil would be burned to supply steam for heat. The fuel is not in short supply. The water to be used for the Savannah River ECF would be withdrawn from the Savannah River and would be a negligible amount. No new water intake structure would be required, and no observed impacts have resulted from previous withdrawals. Total consumption of water attributable to water pool operations and consumption of potable water by operating personnel represent less than one-thousandth of a percent of the Savannah River average annual flow.

The total cost of locating a new ECF at Savannah River is approximately $3.5 billion. This cost represents the total cumulative costs over the 40-year period and includes construction and operations costs of the new ECF as well as the costs associated with shutting down the INEL-ECF. Refer to Section 3.7 for a comparison of the total cumulative costs among alternatives. This cost would be reduced if the Barnwell Plant were selected.

As is the case with the INEL-ECF, construction and operation of the Savannah River ECF would not require the use or consumption of scarce resources.

5.4 HANFORD SITE

5.4.1 Overview of Environmental Impacts

The following sections discuss the potential environmental consequences that would arise if a facility to replace the Idaho National Engineering Laboratory Expended Core Facility (INEL-ECF) were to be constructed and operated at the Department of Energy (DOE) Hanford Site (Hanford ECF). Two options exist at Hanford: build a new ECF between the 200 West and the 200 East Areas, or modify the existing Fuels and Materials Examination Facility (FMEF) in the 400 Area (see Figure 4.4-1). Details of the receipt, handling, and examination of naval spent nuclear fuel at Hanford and the modifications to the FMEF are described in Attachment E. A detailed discussion of the potential environmental consequences of other actions and alternatives at Hanford is contained in Volume 1, Appendix A.

The environmental consequences of constructing and operating the Hanford ECF are based on the same radiological source terms for normal and accidental releases and the estimated atmospheric emissions, liquid effluents, and solid wastes for the INEL-ECF discussed in Section 4.2.

The environmental consequences for the Hanford ECF would be similar to those for the INEL-ECF (see Section 5.2), and none would be large.

5.4.2 Land Use

The Hanford ECF would use essentially the same land area as that which was affected by construction of the INEL-ECF. The structure itself would occupy approximately 5 acres, and the total affected land area would be approximately 30 acres. The higher elevation of the Hanford ECF location relative to a Probable Maximum Flood would reduce the amount of grading and the resulting atmospheric emissions from construction activities.

The land area that would be affected at the Hanford Site has been dedicated through previous operations as a nuclear materials handling area. The land area affected by construction is of the sagebrush vegetation community typical of the arid Hanford Site region. Land areas disturbed by construction but not affected during operation would revert to the natural sagebrush community.

Native American rights and interests may be affected by construction or operations associated with alternatives that involve construction or modification of facilities at the Hanford Site. DOE is assisting Native Americans who have expressed an interest in renewing their use of some Hanford land-use resources, in accordance with the Treaty of 1855. Details are provided in Volume 1, Appendix A.

5.4.3 Socioeconomics

If the Hanford ECF were to be constructed, the potential socioeconomic impacts associated with construction of the facility are expected to be equal to or less than those that were associated with constructing the existing INEL-ECF because: (1) as at the INEL, a large migration of construction workers into the area would not be expected for constructing the project at the Hanford Site due to the availability of construction craft workers who were formerly involved in construction work at the Hanford Site; and (2) the existing population base within 80 kilometers (50 miles) of the Hanford Site is larger than that surrounding the INEL and would provide a larger capability to absorb the incoming construction workers. The estimates of the social and economic requirements of the operational work force expected to be employed during the construction period are small and similar to those estimated for the INEL. Details are available in Volume 1, Appendix A.

Table 5.4-1 provides a summary of the direct jobs which would be required for the construction and operation of the Hanford ECF during the 10-year period immediately after the Record of Decision. The greatest number of direct jobs would occur in 1999 during the peak of the construction phase. Estimates of the indirect jobs created as well as the effect on area population are included in Section 5.5.1 of Volume 1 as part of either the Regionalization or Centralization at Hanford alternatives.

Table 5.4-1. Summary of direct jobs due to the Hanford ECF.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Direct Jobs	20	20	476	825	1033	894	850	500	500	500

During the construction period, operations personnel would be hired so that at the end of the construction period, most of the workers required for operation and support would be employed. When fully staffed, operation of the Hanford ECF would require approximately 500 people, the same number of operating and support personnel as operation of the INEL-ECF. The total operating work force would represent about 3 percent of the Hanford Site employment. The potential economic benefits to the area are expected to be similar to those for the INEL area. The benefits would result from the new jobs that would be created and the associated jobs that would become reinforced (DOE 1986a).

With the small percentage increase in the number of jobs at the Hanford Site attributable to Hanford ECF operations, the impacts to local government services and community infrastructures are expected to be small. Volume 1 quantifies these effects. The beneficial economic impacts to the region are expected to be similar to the economic benefits for the INEL region.

5.4.4 Cultural Resources

Construction at this site would neither impact any known archaeological and historic sites nor disturb any known habitats for rare or endangered species. None of the alternatives considered would impact known archaeological or Native American sites. Procedures which comply with all applicable laws and regulations would be implemented to protect previously undetected archaeological and cultural sites.

5.4.5 Aesthetic and Scenic Resources

The Hanford Site is in a semi-arid region of southeastern Washington. Since 1943, when the site was selected to become the facility for the production of plutonium for the Manhattan Project, the site has been devoted to research, development, and production activities. As a result of its isolated location, its industrial characteristics are not readily visible to the public. The architecture is compatible with the current industrial setting.

5.4.6 Geology

5.4.6.1 General Geology. The local geology of the Hanford region determines the locations of

the surface waters and groundwaters at the site. The geology of the Hanford region is not expected to be affected by the Hanford ECF construction or operations.

5.4.6.2 Geologic Resources. Two geological resources are of particular relevance to the Hanford

Site and to its utility as a location for the Hanford ECF. The water table is located several hundred feet beneath the site. The region between the surface and the water table is an unsaturated zone; it provides an effective barrier between the large aquifer in the groundwater below and the radiological work conducted above. No radiological or hazardous liquid effluent from the Hanford ECF would be discharged to the ground. The operation of the Hanford ECF is not expected to alter the character of the unsaturated zone or the aquifer under the Hanford Site.

5.4.7 Air Resources

The meteorology of the Hanford region is described in Section 4.4.7. There is no potential for the construction and operation of the Hanford ECF to have any impacts on the meteorology of the region.

Consideration of general weather parameters in the Hanford region indicates a high potential for air pollution due to frequent low rates of turbulence or mixing in the atmosphere. The lowest rates of mixing in an atmospheric layer are found in thermally stable layers. Thermally stable conditions occur at Hanford about 44 percent of the time, on the average. Neutral conditions (moderate mixing) occur about 31 percent of the time. The highest rates of mixing (thermally unstable) occur only about 25 percent of the time.

The stagnation that results from low mixing permits an abnormally high concentration of pollutants to accumulate from sources within the region. This applies to ordinary pollutants, such as smoke and other exhaust fumes from regional sources, as well as to airborne emissions from Hanford and a Hanford ECF. The normal emissions from a Hanford ECF would be low enough that the increase that might be accumulated during an inversion would not have any discernible environmental consequence. Less than 1 percent of the total calculated number of fatal cancers in the 80-kilometer (50-mile) population would be due to the normal operations of a Hanford ECF.

Some of the chemicals that are used in the normal operations of an ECF are classified as toxic chemicals. The use of these chemicals is controlled to limit the exposure of workers and the public. Airborne emissions from normal operations include the combustion gases from the boiler house, where fuel is burned to make steam for space heating. Emergency diesel generators are provided for safety, are operated periodically for test purposes, and release exhaust fumes to the atmosphere.

The airborne release of radioactivity for the Hanford ECF would be the same as the INEL-ECF described in Section 5.2. The airborne releases would result in no measurable exposure to on-site personnel or the general public. Details are provided in Attachment F.

Experience with construction activities at Hanford indicates that fugitive dust concentrations at the nearest point of public access and at the site boundaries would be less than the Washington State limits. Standard control techniques such as applying water to the disturbed ground could be used to limit the dust emissions at the construction site.

5.4.8 Water Resources

5.4.8.1 Surface Water. Water required for construction would be withdrawn from the Columbia

River. The amount of water withdrawn from the Columbia River would be negligible in comparison with the 3400 cubic meters per second (120,000 cubic feet per second) annual average flow rate of the river at the Hanford Site. No new water withdrawal intake structure would be required.

Expected surface water withdrawals from the Columbia River during Hanford ECF operations represent small incremental increases in the amount of water currently being withdrawn by ongoing Hanford operations and represent a negligible withdrawal in comparison to the average flow of the Columbia River. There would be no discharge of liquids from the Hanford ECF to either the Columbia or Yakima River.

5.4.8.2 Groundwater. The groundwater at the potential Hanford ECF site is several hundred feet

beneath the surface. This distance provides an ample buffer between the surface operations and the aquifer.

There would be no discharge of radioactive or hazardous liquid effluents from the Hanford ECF to the ground. The existence of contamination in the groundwater due to previous operations at the Hanford Site is discussed in Section 4.4.8.

Sanitary effluents generated during construction would be treated through the use of a septic tank and drain field. Solid non-radioactive and non-hazardous waste resulting from construction would be disposed of on-site at a sanitary landfill. Mitigative and control measures for potential spills and fugitive dust emissions would be undertaken as required.

Sanitary effluents generated as a result of Hanford ECF operations would be discharged to a septic tank located outside of the protected-area fence. Effluent from the septic tank would then be discharged to a sanitary tile field. Other liquid effluents, such as process steam condensate that would be within the limits of DOE and federal standards (DOE 1986b; CFR 1991; CFR 1992a), would be monitored and discharged to a tile field. Liquid effluents meeting these standards and requirements would not result in contamination of groundwater resources.

5.4.9 Ecological Resources

The largest impacts would result from the Centralization alternative. It requires the construction and operation of the Hanford ECF. It is expected that these impacts would be small and similar to those already experienced at Hanford from the construction and operation of other facilities of similar size and scope of operations. The expected impacts are discussed in the following subsections.

5.4.9.1 Terrestrial Ecology. Construction of the Hanford ECF would disturb approximately 30

acres of land, and would permanently occupy 5 acres of land. The remaining land would be revegetated with native grasses. There would be some adverse effect on animal populations, especially the less-mobile animals that might be destroyed during land clearing, but the larger ones would move to another location. The small quantities of radioactivity that would be released are expected to have no effect on man, and are expected to have no effect on the terrestrial organisms. Further discussion is provided in Volume 1, Appendix A.

5.4.9.2 Wetlands. Due to the semi-arid nature of the Hanford environment, there are few affected

wetland areas. They are found along the Columbia River and in local areas at the edges of ponds where the growth of various plants is enhanced. Hanford ECF operations would not have any adverse impact on these areas. Additional information is provided in Volume 1, Appendix A.

5.4.9.3 Aquatic Ecology. There are no aquatic habitats at the potential site for the Hanford ECF.

Hence, there would be no impact on aquatic resources due to construction or operation of the Hanford ECF. Aquatic resources are discussed further in Volume 1, Appendix A. Experience has shown that Hanford operations have not adversely affected its aquatic ecology. The Hanford ECF alternatives are expected to have no adverse impact.

5.4.9.4 Endangered and Threatened Species. Construction and operation of the Hanford ECF

would remove approximately 30 acres of sagebrush habitat until it was revegetated and reestablished after construction. This would impact some members of the species that nest and breed there. Similarly, there would be some impact on vegetation and less-mobile animals, but in general the impacts would be local and the affected animals would be expected to relocate to another suitable habitat on the site. Further discussion and mitigation measures are provided in Volume 1, Appendix A.

5.4.10 Noise

The Hanford Site is a very large area, about 1450 square kilometers (560 square miles), but only about 6 percent of the area is occupied by constructed facilities. Other than the normal noises associated with sparsely spaced industrial facilities and air, rail and road traffic, there is essentially no detectable noise on the site. Construction of the Hanford ECF would cause typical construction noises during the construction period. There would be little or no noise accompanying the normal operations of the Hanford ECF.

5.4.11 Traffic and Transportation

Traffic and transportation would increase slightly in the Hanford area if an ECF is constructed and operated at Hanford. The increased traffic would be mainly due to material shipments during Hanford ECF construction and additional commuter traffic from the construction workers and the operations workers.

The Hanford ECF site would be served by railway and roads. Naval spent nuclear fuel and any irradiated test specimens would be shipped by railway in shielded shipping containers from the shipyard, prototype, or test reactor to the Hanford ECF. There they would be examined and prepared for storage at a DOE facility. Stored fuel and scrap specimens would be stored until they would be shipped to a designated site for disposition. Solid, low-level waste from Hanford ECF handling would be transported by roadway to a Hanford shallow land burial site.

5.4.12 Occupational and Public Health and Safety

The health and safety assessment of normal operations at the Hanford ECF is based on handling spent nuclear fuel for examination and storage by either of two approaches: handling in a water pool or handling in a shielded dry cell. These are the same methods of spent nuclear fuel handling that have been used or were seriously considered for use at the INEL-ECF.

The normal operational impacts associated with the Hanford ECF would be similar to those for the INEL-ECF. The following sections describe the non-radiological and radiological impacts associated with the Hanford ECF (refer to Section 5.2 for the INEL-ECF impacts).

5.4.12.1 Occupational Health and Safety. Projections of the number of occupational accidents

that might occur during construction and operation of naval spent nuclear fuel storage and examination facilities have been made for each alternative. These projections are presented in Attachment F. Based on the results of these projections, it is concluded that the number of occupational fatalities and injuries or illnesses for construction activities and storage and examination operations would be very small for any alternative.

During construction of the Hanford ECF at the Hanford Site, construction personnel would be exposed to a slightly elevated background level of radioactivity resulting from ongoing Hanford Site operations. The maximum additional annual exposure from ongoing operations at the Hanford Site for a construction worker in the vicinity of the 200-East Area would be approximately 2 to 3 millirem if he or she spent 2000 hours per year (40 hours per week for 50 weeks per year) at the Site. This annual exposure of approximately 2 to 3 millirem to a construction worker at the Hanford Site would be well below the DOE standard of 5000 millirem per year for occupational exposure.

During operation of the Hanford ECF, other Hanford personnel would be exposed to routine atmospheric emissions of radioactivity and to potential emissions from accidents. The radiological exposure received by on-site personnel would be below the DOE standard for occupationally related external and internal exposure. Approximately 3000 workers are employed in the 200-East Area within a 1.6-kilometer (l-mile) radius of the Hanford ECF site. Fewer workers are employed near the 400 Area (alternative FMEF site for the Hanford ECF). As shown in Attachment F, the health effects due to exposures received by the collocated worker from normal Hanford ECF operation would be small. Exposures received by Hanford ECF workers are expected to be similar to the exposures that have been received by workers from recent ECF operations at the INEL, discussed in Section 5.2.12.

5.4.12.2 Public Health and Safety. Radiological releases to the atmosphere during normal

operations and the quantities of radioactive and mixed wastes normally generated would be approximately the same as those previously discussed for the INEL. However, the location of the Hanford ECF relative to the surrounding Hanford Site population and the distances to other facilities that would be involved in routine shipments of material would result in small differences in potential environmental consequences.

Assessment of the normal operations of the Hanford ECF involved two options: fuel handling in a water pool or dry cell for examination and storage. For both options considered, the potential annual exposures were estimated for five different types of people: a worker at the Hanford ECF site located 100 meters from the release point, the hypothetical maximally exposed collocated worker on the Hanford Site, the hypothetical maximally exposed off-site individual (MOI), an individual at the nearest public access (NPA), and the population within 80 kilometers (50 miles) of the Hanford ECF site. Three pathways were included in the analysis: airborne, waterborne, and direct radiation, as applicable.

The results indicate that either the water pool or the dry cell option would be satisfactory for normal operations since the exposure is so low. The analysis shows that the exposure to all the individuals considered (workers, collocated workers, MOI, and NPA) from Hanford ECF operations would be much less than 1 millirem per year. For perspective, it could be stated that one member of the entire population might experience a fatal cancer due to Hanford ECF operations if operations continued for over 200,000 years. A description of the analysis methods and more detailed results are provided in Attachment F. The impacts from normal operations for all alternatives are summarized in Section 3.7.

The radiological and non-radiological health effects associated with the incident-free transportation of naval spent nuclear fuel and test specimens have been assessed for the general population, transportation workers, and hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancers as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. The details of the transportation analysis are provided in Attachment A.

5.4.12.3 Incident-free Occupational and Public Health and Safety Effects on Environ-

mental Justice Due to Naval Spent Nuclear Fuel Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from normal operations associated with the examination of naval spent nuclear fuel at the Hanford Site would be small under any of the alternatives considered. For example, it is unlikely that a single fatal cancer would occur as a result of activities associated with naval spent nuclear fuel examination under any alternative. Since the potential impacts due to normal operations or accident conditions for any of the alternatives considered present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is true for normal operations because the effects of routine operations are so small. It is also true for accident conditions because the consequences of any accident would depend on the random conditions at the time it occurred, and the wind directions at the Hanford Site do not display any strongly dominant direction. Similarly, the conclusion is not affected by concerns related to subsistence consumption of fish or game because of the very small impacts associated with examination of naval spent nuclear fuel.

To place the impacts on environmental justice in perspective, the risk associated with routine operations for naval spent nuclear fuel examination under any of the alternatives considered would be less than one fatality per year for the entire population. For comparison, in 1990 there were approximately 510,000 cancer deaths in the United States population and there were about 64,000 cancer deaths among people of color in the U. S. Even if all of the impacts associated with one of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would be unlikely to experience a single additional cancer fatality in any year. Therefore, the cancer risk for that population from naval spent nuclear fuel management would not constitute a disproportionately high and adverse impact on human health or the environment. The same conclusion can be drawn for low-income groups.

5.4.13 Utilities and Energy

Heating, ventilation, and electrical systems appropriate to the needs of the Hanford ECF for suitable working environments and to properly filter and exhaust the airborne discharges to the atmosphere are estimated to require approximately 10,000 MWh per year for normal operations. Emergency diesel electrical generators would provide 350 kw for life support and crucial facility services during power outages. The increase in electrical power needs might create the demand for additional capacity. The amount of energy consumed would be a small fraction of the total energy used at the Hanford Site, and no discernible environmental consequence is expected.

5.4.14 Facility and Transportation Accidents

The potential consequences and risks of accidents for the Hanford ECF compared to the INEL-ECF are related to the meteorological transport of released material, the population exposed, and (for the transport of naval spent nuclear fuel and any test specimens) the distance of transport.

The following sections address the major potential accident consequences and risks associated with the Hanford ECF compared to the INEL-ECF.

5.4.14.1 Facility Accidents. The accident scenarios for the Hanford ECF are the same as those

considered for the existing ECF at the INEL. These include radiological accidents which could occur during water pool and dry handling of spent nuclear fuel as well as accidents involving toxic chemicals used at ECF. The radiological accidents analyzed included: (1) an inadvertent criticality caused by an earthquake or similar catastrophic event, (2) accidental loss of large amounts of water containing radioactive material from a water pool into the ground and then into water sources, and (3) severe damage of spent fuel if it were dropped from a crane during handing or had a heavy object dropped on it. The probability of an accident caused by an airplane crash was calculated for the Hanford ECF and was determined to be less than 10-7. Due to the low probability, no consequences were calculated for this accident. Calculations of the cancer fatalities which might occur as a result of all the postulated accidents are provided in Attachment F. A comparison of the accident consequences for all alternatives is provided in Section 3.7.

The difference in the calculated consequences for accidents at the Hanford ECF compared to the INEL-ECF is that the exposure received by the entire population tended to be greater at the Hanford ECF due to the larger population within an 80-kilometer (50-mile) radius of the Hanford ECF project site. Although the exposure received was greater at the Hanford ECF, it is unlikely that any health effects would result from any of the accidents considered. As was the case with the INEL-ECF, the most limiting of the postulated accidents for the Hanford ECF was water pool drainage, ultimately resulting in fuel overheating. The exposure to the entire population from this accident is calculated to cause 0.047 cancer fatalities over 50 years, as described in Attachment F. This amounts to an approximately 5-percent chance of one cancer fatality in 50 years from this potential accident.

The exposures to collocated workers following any accident are well below the naval and DOE 5-rem standard for occupational exposure. However, exposures to the worker located at the Hanford ECF site 100 meters from the radiation release point would exceed this standard following an accident resulting in an inadvertent criticality.

The effects from accidents involving the use of toxic chemicals at the Hanford ECF are similar to those described in Section 5.2.14 for the INEL-ECF. The same amount and types of chemicals stored and used at the INEL-ECF would be used at the Hanford ECF, so toxic chemicals would not pose a risk to the public following any of the postulated accidents. However, following the maximum foreseeable accident analyzed (a fire transient), a number of toxic chemicals would exceed the Emergency Response Planning Guideline (ERPG) values for workers on the Hanford ECF site as well as collocated workers. For the maximum off-site individual (MOI), EPRG-1 values for the toxic chemicals are not exceeded under 50-percent or 95-percent meteorology conditions. The concentrations of toxic chemicals following the fire transient and a summary of the analysis methods are provided in Attachment F.

5.4.14.2 Transportation Accidents. The health effects associated with accidents during

shipments of naval spent nuclear fuel and test specimens have been assessed for the general population and hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancer as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. However, the most severe accident with a likelihood of occurrence greater than 1 x 10-7 events per year is estimated to result in a maximum of approximately 2 cancer fatalities. The details of the transportation analysis are provided in Attachment A.

5.4.14.3 Other Impacts of Accidents. In addition to the possible human health effects

associated with facility or transportation accidents described in the preceding sections, other effects such as the impacts on socioeconomics and land use in the area and the costs of cleanup have been estimated in order to develop a perspective and to evaluate potential differences among alternatives.

The analyses described in Attachment F showed that for the most severe hypothetical accidents, an area of between about 8 acres extending about 1/4 mile downwind (for an accidental criticality) and approximately 210 acres extending about 1 1/4 mile downwind (for a large airplane crash into the fuel examination facility) might be contaminated to the point where exposure could exceed 100 millirem per year. Beyond these distances, the exposure would be less than 100 millirem per year, the Nuclear Regulatory Commission's standard for protection of the general population from radiation. Persons who work at locations within this area might be prevented from going to their jobs at the federally owned facilities until measures had been taken to reduce the potential for exposure.

The area affected by the hypothetical accidents would not extend beyond the boundaries of the federally owned Hanford Site. An accident might result in short-term restrictions on access to a relatively small area, but it would not be expected to produce any enduring impacts on cultural or similar resources or concerns such as Native American rights or interests, partially because the area involved would be small and partly because all remedial actions would be conducted in a careful, controlled manner in full compliance with applicable laws and regulations. The area would vary only slightly among alternatives. Overall, the risks are small so these considerations do not assist in distinguishing among alternatives.

Facility or transportation accidents associated with an Expended Core Facility at the Hanford Site would not have an appreciable effect on the ecology of the area, considering the potential for human health effects and the amount of land which might be affected, as described in earlier parts of this section. There is little consensus among scientists on methods for estimating the effects of radiation on ecological resources such as plant or animal life, but since human health effects for all the accidents analyzed are small and most plants and animals are not thought to be more sensitive to radiation than human beings, the small impacts on human health provide an indication that the impacts on animal and plant species in the area would also be small for an alternative which would relocate the Expended Core Facility to the Hanford Site. Similarly, since the areas which might be contaminated to measurable levels by chemicals or radioactive material during the hypothetical accidents would be relatively small, any effects on the ecology would be limited to small areas. As previously stated, there are no endangered or threatened species unique to the area surrounding the location considered for a replacement Expended Core Facility at the Hanford Site, so an accident would not be expected to result in destruction of any species. The effects of accidents related to any of the alternatives and any cleanup which might be performed would be localized in a small area which would not extend beyond a relatively short distance from the Expended Core Facility and thus would not be expected to appreciably affect the potential for survival of endangered or threatened species in the Hanford area. Based on these considerations, evaluation of impacts of accidents on ecological resources does not help to distinguish among alternatives.

5.4.14.4 Effects of Accidents on Environmental Justice Due to Naval Spent Nuclear Fuel

Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from facility or transportation accidents associated with the management of naval spent nuclear fuel at the Hanford Site would be small under any of the alternatives considered. For example, it is unlikely that a single additional fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to an accident for any of the alternatives considered would present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects from accidents associated with the management of naval spent nuclear fuel would be expected for any particular segment of the population, minorities and low-income groups included.

To place the impacts on environmental justice in perspective, the risk from hypothetical accidents associated with naval spent nuclear fuel examination under any of the alternatives considered would amount to less than one additional fatality per year in the entire population. For comparison, in 1990 there were approximately 40,000 traffic fatalities in the United States population and there were about 7,400 deaths caused by traffic accidents among people of color in the U. S. Even if all of the additional cancer deaths associated with an accident involving any of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would experience less than one additional fatal cancer per year. The same conclusion can be drawn for low-income groups.

5.4.15 Waste Management

During Hanford ECF operations, non-radioactive and non-hazardous solid waste and hazardous solid waste would be generated in quantities similar to those for the INEL-ECF. These wastes would be managed in a manner identical to that for the INEL-ECF (that is, non-hazardous, non-radioactive solid wastes would be disposed of at a sanitary landfill, and hazardous wastes would be contained at their point of generation and transported off-site to an approved treatment, storage, and disposal facility). During normal waste management practices for these wastes, no identifiable impact on public health and safety or the environment would occur.

Operation of the Hanford ECF would generate essentially the same quantities of low-level waste, transuranic waste, and mixed wastes as discussed for the INEL. Additional information on materials and waste management at Hanford is provided in Volume 1, Appendix A.

5.4.16 Cumulative Impacts

The potential environmental consequences of constructing and operating the Hanford ECF are discussed above in terms of annual impacts (that is, radiological exposures and health effects, accident risks, and quantities of wastes that would be generated during operation) based on the evaluation of operating experiences at the INEL-ECF. This section provides a discussion of the potential consequences of up to 40 years of operation of the Hanford ECF (from 1995 to 2035).

5.4.16.1 Radiological Cumulative Impacts. Operation of the Hanford ECF would not result in

discharges of radioactive liquids; therefore, there would be no changes to the surface or ground water as a result of normal operations for any alternative. There would be small quantities of radioactivity in the air released from the Hanford ECF which would contribute to the cumulative air quality impacts. The Hanford Site has not been used for naval spent nuclear fuel operations in the past. Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

The annual radiological impacts associated with the alternatives where naval spent nuclear fuel would be inspected or stored at Hanford Site are very small and are described in Section 5.4.12, with the detailed results of analyses provided in Attachment F. In order to calculate cumulative impacts for the period between 1995 and 2035, the annual radiological impacts associated with each location and alternative were summed over 40 years. The results of this summation are tabulated in Tables 3-5 and 3-6 of Section 3.

The cumulative transportation impacts for the population groups from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated and are very small. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A and summarized in Section 3.7.4.

The total exposure to the general public from transportation and from Hanford ECF operations would be about 5 person-rem. This means that there would be about 0.0025 fatal cancers from these operations over the entire 40-year period evaluated. The exposure to the maximally exposed off-site individual would be less than 0.02 millirem from 40 years of Hanford ECF operation at either the 200 Area or the FMEF. The corresponding risk of a cancer fatality to the maximally exposed off-site individual is 4.8 x 10-9 at the 200 Area and 8.8 x 10-9 at the FMEF during his or her lifetime. A worker at the Hanford ECF site located 100 meters from the facility would receive less than 4 millirem over 40 years of Hanford ECF operation, which corresponds to a 1.4 x 10-6 risk of fatal cancer during the worker's lifetime. These exposures and cancer risks are as a result of ECF operations only. The exposures and risks corresponding to site-wide operations (including ECF) are discussed in Volume 1, Chapter 5. Analyses of hypothetical accidents which might occur as a result of these alternatives show that the risk of cancer fatalities is small. The impacts associated with transportation of naval spent nuclear fuel for all of the alternatives considered would be similarly low.

No contribution to cumulative impacts from accidents involving naval spent nuclear fuel has been included in the analyses presented in this Environmental Impact Statement because there has never been a nuclear reactor accident, criticality accident, transportation accident, or any release of radioactivity which had a significant effect on the environment.

Cumulative impacts due to radioactive waste generation are expected to be minimal. Approximately 425 cubic meters of low-level waste are expected to be generated annually by the Hanford ECF over the next 40 years. This is not expected to affect the Hanford waste management program. Very little transuranic waste or mixed waste and no high-level waste will be generated from Hanford ECF operations.

5.4.16.2 Non-radiological Cumulative Impacts. The cumulative socioeconomic impacts

associated with constructing and operating the Hanford ECF are expected to be small. The Hanford Site currently employs over 18,000 people. In the past, no employment at the Hanford Site has been associated with naval spent nuclear fuel operations. Hanford ECF operations would provide long-term employment for 500 people at the Hanford Site. The peak number of additional jobs created at the Hanford Site in any given year would be approximately 1050, which includes both construction and operations workers during the peak of the Hanford ECF construction effort. Considering that the labor force in the region of influence consists of approximately 88,000 people, the additional number of jobs added from the construction and operation of the Hanford ECF would be expected to have only a minor socioeconomic impact in the Hanford area.

Construction and operation of the Hanford ECF are not expected to result in any impacts from cumulative hazardous or toxic emissions. Construction would be sufficiently remote from the nearest site boundaries such that concentrations of any fugitive construction emissions would be well below applicable standards, as discussed in Section F.4 of Attachment F. Current operations at the Hanford Site are in compliance with Title 40, Code of Federal Regulations, Part 61, "National Emission Standards for Hazardous Air Pollutants." Cumulative air emissions would not threaten to exceed any applicable air quality requirement or regulation, either federal, state, or local in radiological and non-radiological categories.

As discussed in Section 5.4.8, the withdrawal of surface water for construction and operation of the Hanford ECF would be a small percentage of existing withdrawals and well within the cumulative capabilities of the respective water resources. Discharges of ECF non-radioactive and non-hazardous liquid effluents to tile fields at the Hanford Site are not expected to impact groundwater quality (that is, either of itself or on a cumulative basis).

Minimal cumulative land use impacts would be expected to occur as a result of the construction of a new ECF at Hanford. The land that would be dedicated for this purpose is on existing federal property. The use of this land would not result in the need for additional land to be added to the federally owned property in the foreseeable future. The Hanford Site occupies an area of approximately 1450 square kilometers (560 square miles) with only about 6% of the land occupied by constructed facilities. No land area at the Hanford Site has been affected by past operations involving naval spent nuclear fuel. Construction of the Hanford ECF would affect 30 acres of land. This is less than 0.01% of the total Hanford Site land area.

The cumulative impacts associated with non-radiological waste management are expected to be small. The volume of hazardous waste produced by ECF has not been calculated; however, considering the nature of the work associated with ECF, the amount of hazardous waste produced would have a small effect on the cumulative impacts associated with this waste. The volume of municipal solid wastes and sanitary wastes which would be generated is expected to be proportional to the number of additional workers added, and this small incremental increase would not be discernible. The amount of non-radiological wastes generated would not introduce any changes to the site's waste management practices and would not impose any additional stress on the capacity of on-site or off-site waste disposal or treatment facilities. Therefore, any cumulative impacts associated with the generation and disposal of additional wastes would be very small. There are no current environmental problems associated with these types of wastes.

5.4.17 Unavoidable Adverse Effects

Construction of the Hanford ECF would directly impact a total of about 120,000 square meters (30 acres) of land area previously dedicated to the handling of nuclear materials, and approximately 400,000 square meters (100 acres) outside the protected site area for the construction of a transmission line and tile field. During construction, plant and animal habitats associated with a sagebrush vegetation community would be lost or displaced from areas not previously disturbed. None of the land area outside the protected site area associated with the construction of the transmission line and less than half of the land area within the protected site area would be affected by operation; the rest would revert to a sagebrush vegetation community through natural plant succession. Modification of the FMEF would have lesser impacts because the construction work would be less extensive. Refer to Attachment E for details.

Construction of the Hanford ECF would also generate liquid effluents, atmospheric emissions, and solid wastes typical of those for construction of a major industrial facility. All effluents and emissions would be below applicable environmental requirements and would not be expected to result in any adverse impact.

During operation of the Hanford ECF, unavoidable radiation exposures would include occupational exposures and exposures to the public from normal atmospheric emissions of radioactive materials that would be minimal compared to the criteria imposed by the "Environment, Safety, and Health Program for Department of Energy Operations" (DOE 1986b) and the "National Emission Standard for Hazardous Air Pollutants" (CFR 1992b). Sanitary and service waste liquid discharges that would eventually be discharged to the soil column through tile fields would all be below applicable environmental standards, including radioactivity standards for drinking water. Solid wastes generated during operation, including transuranic, low-level, hazardous, and mixed wastes, would result in small increases in potential exposures to radioactive and hazardous materials. Freon emissions would be controlled, but might result in a negligible increase in the risk of skin cancer; substitutes would be used when available.

In general, the unavoidable adverse impacts would be few and limited, and none have been identified that would affect public health and safety.

5.4.18 Irreversible and Irretrievable Commitments of Resources

During operation of the Hanford ECF, additional fuel would be burned to supply steam, similar to the levels experienced at the INEL-ECF. The water to be used for the Hanford ECF would be withdrawn from the Columbia River. The amount of water that would be withdrawn from the Columbia River would be negligible. No new water withdrawal intake structure would be required and no observed impacts have resulted from previous withdrawals. Total consumption of water attributable to water pool operations and consumption of potable water by operating personnel represent less than one-thousandth of a percent of the Columbia River average flow rate.

The total cost of locating a new ECF at Hanford would be approximately $3.4 billion. This cost represents the total cumulative cost over the 40-year period and includes construction and operations costs of the new ECF as well as the cost associated with shutting down the INEL-ECF. If the FMEF were to be modified for use as the Hanford ECF, the cost would be less. Refer to Section 3.7 for a comparison of the total cumulative costs among alternatives.

Construction and operation of the Hanford ECF would not require the use or consumption of scarce resources. Expected withdrawals of surface water and groundwater during construction and operation would represent small incremental increases in the amounts of water being withdrawn by ongoing Hanford operations.

5.5 OAK RIDGE RESERVATION

5.5.1 Overview of Environmental Impacts

The following sections discuss the potential environmental consequences that would occur if a replacement for the Expended Core Facility (ECF) at the Idaho National Engineering Laboratory (INEL) were constructed and operated at the Department of Energy's Oak Ridge Reservation (ORR). This replacement will be referred to as Oak Ridge ECF. The new ECF would be sited near the K-25 Site which is located on the western portion of the ORR (see Figure 4.5-1 of Section 4.5).

The environmental consequences of locating and operating the ECF at ORR are based on the same radiological source terms for normal and accidental releases and the estimated atmospheric emissions, liquid effluents, and solid wastes discussed in Section 5.2 for the ECF at INEL. The environmental consequences of locating and operating the ECF at ORR would be similar to those for the ECF at INEL, and none would be large.

5.5.2 Land Use

Construction of an ECF at ORR would directly affect about 30 acres of land near the already highly developed K-25 Site area. Site preparation for construction would disturb areas of natural vegetation cover which primarily include oak/hickory forest land. The direct loss of terrestrial habitat would be minimized to the extent practical. Following completion of construction, the grounds around the ECF would be landscaped with trees and shrubbery in a manner consistent with other facilities in the K-25 Site area. The affected land area is very small compared to the entire ORR.
Native American rights and interests would not be modified by construction or operation of the Oak Ridge ECF.

5.5.3 Socioeconomics

The potential socioeconomic impacts associated with construction of the ECF at ORR are expected to be equal to or less than those associated with the original ECF construction at INEL because (1) a large movement of construction workers from other areas would not be expected for the Oak Ridge ECF construction due to the availability of construction craft workers in the ORR region and (2) the existing population base within 80 kilometers (50 miles) of the ORR is larger than that surrounding the INEL area and would provide a greater capability to absorb the incoming construction personnel.

Table 5.5-1 provides a summary of the direct jobs which would be associated with construction and operation of the Oak Ridge ECF during the 10-year period immediately following the Record of Decision. The greatest number of direct jobs would occur in 1999 during the peak of the construction phase. Estimates of the indirect jobs created as well as the effect on area population are included in Chapter 5 of Volume 1 for Regionalization at the ORR and for Centralization at the ORR.

Table 5.5-1. Summary of direct jobs due to Oak Ridge ECF construction and operation.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Direct Jobs	20	20	476	825	1033	894	850	500	500	500

During the Oak Ridge ECF construction period, operations workers would be hired so that at the end of the construction period, most of the 500 operations personnel would be employed. The percentage of operations workers expected to move into the area from other areas varies based on skill requirements. Overall, approximately 20 percent are estimated to move into the ORR area. The four-county region of influence around the ORR had a 1990 population of 489,230 persons, or more than twice that of the INEL.

ECF operations at the ORR would require essentially the same number of operations personnel as at the INEL. This would represent less than 3 percent of the total ORR work force. Given an average family size of 2.6 persons per household for operations personnel moving into the area, the expected population increase attributable to operations personnel would represent about 14 percent of the average annual growth rate from 1980 to 1990 in the ORR's four-county region of influence. This percentage of population increase attributable to Oak Ridge ECF operations in relation to normal population increases in the ORR region might have a short-term, minor impact on local government services and community infrastructures. The economic benefits to the ORR region are expected to be similar to or less than those for the INEL region since the existing economic base of the ORR region is greater and more diverse than that of the INEL region.

5.5.4 Cultural Resources

Construction or operation of the Oak Ridge ECF would not impact known archaeological or Native American sites. Procedures which comply with all applicable laws and regulations would be implemented to protect previously undetected archaeological and cultural sites.

5.5.5 Aesthetic and Scenic Resources

Construction of the Oak Ridge ECF would directly affect 30 acres of land. The proposed facility would be seen from Bear Creek Road as being completely surrounded by undeveloped areas. The forested ridges to the northwest and southeast of this area reduce its visibility from privately owned lands, so that impacts to aesthetic and scenic resources would be minor.

5.5.6 Geology

5.5.6.1 General Geology. Although some ripping or blasting of limestone, dolomite, or quartz

layers could be necessary to construct the ECF, no unique geological features would be affected. There are no mining activities in this vicinity that could be impacted by ECF construction or operation. Previously disturbed areas would be regraded to accommodate the new ECF. Sediment runoff from such land disturbances would be minimized by implementation of soil erosion and sediment control measures.

5.5.6.2 Geologic Resources. Since no extensive or unique geologic or mineral resources are

known to occur near the K-25 Site, impacts to such resources from ECF construction or operation would not be expected.

5.5.7 Air Resources

Minor short-term emissions of fugitive dust and exhaust from heavy equipment would be possible during Oak Ridge ECF construction. The use of toxic chemicals during ECF normal operations is controlled to limit the exposure of workers and the public. Airborne emissions from normal operations would include the combustion gases from the boiler house, where fuel would be burned to make steam for space heating. Emergency diesel generators, which would be provided for safety, would be operated periodically for test purposes and release exhaust fumes to the atmosphere. The environmental impacts of these emissions would be negligible.

The airborne releases of radioactivity for the ECF at ORR would be the same as for the ECF at INEL described in Section 5.2. The airborne release would result in no measurable exposure to on-site personnel or the general population. Details are provided in Attachment F.

5.5.8 Water Resources

5.5.8.1 Surface Water. Water required for construction of the Oak Ridge ECF would be withdrawn from the Clinch River. The small amount of water withdrawn would be negligible in comparison to the approximately 1.29 x 1010 liters (3.40 x 109 gallons) per day flow at the Melton Hill Dam. No new water intake structure would be required.

The 2.5 million gallons per year additional surface water withdrawal from the Clinch River during Oak Ridge ECF operations would represent a very small increase in the 6.93 x 107 liters (1.83 x 107 gallons) per day currently being withdrawn by ongoing ORR operations and represent a negligible withdrawal in comparison to the average flow of the Clinch River.

Liquid discharges from the Oak Ridge ECF would be treated by a wastewater treatment plant which would be built to service the new DOE spent nuclear fuel facilities. Discharges of treated wastewater to area receiving waters would be in accordance with applicable National Pollutant Discharge Elimination System effluent limits. These discharges would have a negligible impact on the receiving water system. Design controls would render spills and leaks that could contaminate surface or groundwater unlikely.

The Oak Ridge ECF would not be located within the 500-year floodplain.

5.5.8.2 Groundwater. No groundwater would be used for construction and operation of the Oak Ridge ECF, given the plentiful surface water supplies. Therefore, no impact on groundwater levels or quantity is expected. Because there would be no direct discharge of process water to groundwater, and because wastewater would be treated prior to a National Pollutant Discharge Elimination System-permitted discharge to surface waters, no impacts on groundwater are expected.

5.5.9 Ecological Resources

5.5.9.1 Terrestrial Ecology. Areas of natural vegetation cover which primarily include oak/hickory forest land would be disturbed for the Oak Ridge ECF. The loss of terrestrial habitats would be minimized to the extent practical. Construction and traffic noise might have a short-term, minor impact on wildlife beyond the immediate construction site.

During construction and operation of the Oak Ridge ECF, all effluents and emissions would comply with regulatory standards and are not expected to have an impact on the area wildlife. Operation of the Oak Ridge ECF should result in less noise and traffic than the construction phase, and no effects on terrestrial ecology are expected from Oak Ridge ECF operations.

5.5.9.2 Wetlands. Construction of the Oak Ridge ECF may displace forested wetlands adjacent to tributaries of Grassy Creek flowing near the proposed site. This displacement of wetlands would be accomplished in accordance with Corps of Engineers and Tennessee Water Quality Control Administration requirements.

5.5.9.3 Aquatic Ecology. Aquatic habitat would be affected by the rechanneling of tributaries to Grassy Creek during construction of the Oak Ridge ECF. Minor increases in water withdrawal from the Clinch River and water discharged to its tributaries would not greatly affect the aquatic ecology of these water bodies. All wastewater would be discharged in compliance with National Pollutant Discharge Elimination System permit limitations.

5.5.9.4 Endangered and Threatened Species. No known terrestrial or aquatic areas potentially

providing habitat to federally listed or state listed threatened or endangered species are found in the construction area; consequently, impacts to threatened and endangered species are not expected to be a concern.

5.5.10 Noise

Noises generated on the ORR do not propagate off-site at levels that impact the general population. Noise increases outside the ORR due to the Oak Ridge ECF would be limited to those produced by truck, car, and train traffic on roads and railroads approaching the ORR. These increases would not be large enough to be objectionable to the communities bordering the roads and railroads.

5.5.11 Traffic and Transportation

Traffic and transportation would increase slightly in the ORR area if an ECF were constructed and operated at ORR. The additional traffic would mainly be due to increased commuter traffic from construction workers and 500 operations workers as well as traffic from material shipments during Oak Ridge ECF construction and operation.

If the Oak Ridge ECF were established, naval spent nuclear fuel would be routinely transported to the ORR in certified shipping containers. Various types of wastes generated at the ECF would be dispositioned on-site and off-site. Following examination, most of the spent nuclear fuel would be transferred to the spent fuel storage location at ORR until the time that permanent geologic storage becomes available.

5.5.12 Occupational and Public Health and Safety

The health and safety assessment of normal operations at the Oak Ridge ECF was based on handling and examination of naval spent nuclear fuel either in a water pool or in a dry cell. These are the same methods of spent nuclear fuel handling that have been employed or seriously considered for use at the ECF at INEL. The normal operational impacts associated with the ECF at ORR would be similar to those for the ECF at INEL. The following sections describe the non-radiological and radiological impacts associated with the ECF at ORR (refer to Section 5.2 for the ECF at INEL impacts).

5.5.12.1 Occupational Health and Safety. Projections of the number of occupational accidents

that might occur during construction and operation of naval spent nuclear fuel storage and examination facilities have been made for each alternative. These projections are presented in Attachment F. Based on the results of these projections, it is concluded that the number of occupational fatalities and injuries or illnesses for construction activities and storage and examination operations would be very small for any alternative.

During Oak Ridge ECF construction, workers are not expected to experience elevated background levels of radiation resulting from ongoing ORR operations. The potential exposure to a construction worker from inhalation of radionuclides released to the atmosphere from existing ORR operations is expected to be small compared to the external exposure. The exposure received by a construction worker would be well below the naval and Department of Energy (DOE) standard of 5000 millirem per year for occupationally related whole-body and internal exposures.

During operation of the Oak Ridge ECF, ORR personnel would be exposed to routine atmospheric emissions of radioactivity and might be exposed to potential emissions from accidents. The Oak Ridge ECF site is located approximately 1 mile from the nearest ORR facility. As shown in Attachment F, no measurable exposure would be received by these collocated workers from normal Oak Ridge ECF operations. Exposures received by radiation workers from normal operation of the ECF at ORR are expected to be similar to the exposures currently received by workers from normal operation of the ECF at INEL, discussed in Section 5.2.12.

Exposures, injuries, and potential fatalities to workers at the Oak Ridge ECF could also occur as a result of accidents during ECF operations. However, the safety record of the ECF at INEL is very good, and similar safe working conditions could be established at the new facility.

5.5.12.2 Public Health and Safety. The impacts of normal operation of the ECF at ORR would

be similar to those for the ECF at INEL. Normal radiological releases to the atmosphere and the quantities of radioactive and hazardous wastes that would be generated would not differ from those previously discussed for the INEL. However, location of the ECF relative to the surrounding ORR population and the distances to facilities that would be involved in routine shipments of material would result in differences in potential environmental consequences. Described below are the impacts to the public associated with operation of the ECF at ORR (refer to Section 5.2.12 for the ECF at INEL impacts).

Assessment of normal operation of the Oak Ridge ECF involved handling and examination of spent fuel either in a water pool or in a dry cell. For both cases, the potential annual exposures were estimated for five different types of people: a worker at the Oak Ridge ECF site located 100 meters from the release point, the hypothetical maximally exposed collocated worker on the ORR site, the hypothetical maximally exposed off-site individual, an individual at the nearest public access, and the population within 80 kilometers (50 miles) of the Oak Ridge ECF site. Three pathways were included in the analysis: airborne, waterborne, and direct radiation, as applicable.

The results indicate that handling and examination of spent fuel either in a water pool or in a dry cell would be satisfactory for normal operations since the exposure is so low. The analysis shows that the exposure to all the individuals considered (workers, collocated workers, and off-site individuals) from Oak Ridge ECF operations would be much less than 1 millirem per year. For perspective, it could be stated that one member of the entire population might experience a fatal cancer due to Oak Ridge ECF operations if operations continued for 20,000 years. A description of the analysis methods and more detailed results are provided in Attachment F. The impacts from normal operations for all alternatives are summarized in Section 3.7.

The radiological and non-radiological health effects associated with the incident-free transportation of naval spent nuclear fuel and test specimens have been assessed for the general population, transportation workers, and hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancers as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. The details of the transportation analysis are provided in Attachment A.

5.5.12.3 Incident-free Occupational and Public Health and Safety Effects on Environ-

mental Justice Due to Naval Spent Nuclear Fuel Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from normal operations associated with the examination of naval spent nuclear fuel at the ORR would be small under any of the alternatives considered. For example, it is unlikely that a single fatal cancer would occur as a result of activities associated with naval spent nuclear fuel examination under any alternative. Since the potential impacts due to normal operations or accident conditions for any of the alternatives considered present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is true for normal operations because the effects of routine operations are so small. It is also true for accident conditions because the consequences of any accident would depend on the random conditions at the time it occurred, and the wind directions at the ORR do not display any strongly dominant direction. Similarly, the conclusion is not affected by concerns related to subsistence consumption of fish or game because of the very small impacts associated with examination of naval spent nuclear fuel.

To place the impacts on environmental justice in perspective, the risk associated with routine operations for naval spent nuclear fuel examination under any of the alternatives considered would be less than one fatality per year for the entire population. For comparison, in 1990 there were approximately 510,000 cancer deaths in the United States population and there were about 64,000 cancer deaths among people of color in the U. S. Even if all of the impacts associated with one of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would be unlikely to experience a single additional cancer fatality in any year. Therefore, the cancer risk for that population from naval spent nuclear fuel management would not constitute a disproportionately high and adverse impact on human health or the environment. The same conclusion can be drawn for low-income groups.

5.5.13 Utilities and Energy

Heating, ventilation, and electrical systems appropriate to the needs of the Oak Ridge ECF for suitable working environments and to properly filter and exhaust the airborne discharges to the atmosphere are estimated to require approximately 10,000 MWh per year for normal operations. Emergency diesel electrical generators would provide 350 kw for life support and crucial facility services during power outages. The amount of energy consumed would be a small fraction of the total energy used at ORR and no discernible environmental consequence is expected.

5.5.14 Facility and Transportation Accidents

The differences in the potential consequences and risks of accidents at the ECF at Oak Ridge compared to the ECF at INEL are related to the meteorological transport of released material, the population exposure, and the distance of transport. The following sections address the potential accident consequences and risks associated with locating an ECF at the ORR.

5.5.14.1 Facility Accidents. A number of hypothetical accidents were evaluated for the Oak

Ridge ECF. These included radiological accidents involving naval spent nuclear fuel during water pool storage, dry storage, and dry cell operations as well as accidents involving toxic chemicals used at ECF. Calculations of the cancer fatalities which might occur as a result of all the postulated accidents are provided in Attachment F. A comparison of the accident consequences for all alternatives is provided in Section 3.7.

The difference in the calculated consequences for accidents at the ECF at ORR compared to the ECF at INEL is that the exposure received by the entire population would be greater at the Oak Ridge ECF due to the larger population within an 80-kilometer (50-mile) radius of the Oak Ridge ECF site. Although the exposure received was greater at the Oak Ridge ECF, the number of health effects which would result from any of the accidents considered would be small. The most limiting of the postulated accidents for the ECF at Oak Ridge would be an airplane crash into a dry cell facility. The exposure to the entire population from this accident is calculated to cause 8.4 cancer fatalities over 50 years, as described in Attachment F. The risk associated with the airplane crash would be approximately 0.000008 fatal cancers per year.

Effects from two accidents at the ECF at Oak Ridge involving toxic chemicals were evaluated in Attachment F. The first accident was a chemical spill and fire; the second was a fire involving diesel fuel. Both accidents could expose the public to various toxic chemicals at concentrations which exceed Emergency Response Planning Guidelines (ERPG) level 3 limits. Both accidents could also expose workers at the Oak Ridge ECF to various toxic chemicals at concentrations which exceed ERPG-3 limits. In both cases, however, it is expected that actual toxic chemical exposures would be much less due to the mitigative measures that would be implemented. A summary of the analysis methods, the toxic chemical concentrations, and a discussion of the mitigative measures for toxic chemicals are provided in Attachment F.

5.5.14.2 Transportation Accidents. The health effects associated with accidents during

shipments of naval spent nuclear fuel and test specimens have been assessed for the general population and hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any health effects as a result of naval spent nuclear fuel and test specimen shipments since the risk estimates are much less than one fatal cancer or health detriment for each alternative. However, the most severe accident, with a likelihood of occurrence greater than 1 x 10-7 events per year, is estimated to result in a maximum of 2.1 fatalities. The details of the transportation analysis are provided in Attachment A.

5.5.14.3 Other Impacts of Accidents. In addition to the possible human health effects

associated with facility or transportation accidents described in the preceding sections, other effects such as the impacts on socioeconomics and land use in the area and the costs of cleanup have been estimated in order to develop a perspective and to evaluate potential differences among alternatives.
The analyses described in Attachment F showed that for the most severe hypothetical accidents, an area of between about 8 acres extending about 1/4 mile downwind (for an accidental criticality) and approximately 210 acres extending about 1 1/4 mile downwind (for a large airplane crash into the fuel examination facility) might be contaminated to the point where exposure could exceed 100 millirem per year. Beyond these distances, the exposure would be less than 100 millirem per year, the Nuclear Regulatory Commission's standard for protection of the general population from radiation. The area which might be affected by one of these hypothetical accidents could extend slightly beyond the boundaries of the Oak Ridge Reservation, so some people who live in the affected area might be evacuated or otherwise experience restrictions in their daily activities, and those who work at locations within the affected area might be prevented from going to their jobs until measures had been taken to reduce the potential for exposure.

An accident might result in short-term restrictions on access to a relatively small area, but it would not be expected to produce any enduring impacts on cultural or similar resources or concerns such as Native American rights or interests, partially because the area involved would be small and partly because all remedial actions would be conducted in a careful, controlled manner in full compliance with applicable laws and regulations. The area would vary only slightly among the alternatives. Overall, the risks are small so these considerations do not assist in distinguishing among alternatives.

Facility or transportation accidents associated with an Expended Core Facility at the Oak Ridge Reservation would not have an appreciable effect on the ecology of the area, considering the potential for human health effects and the amount of land which might be affected, as described in earlier parts of this section. There is little consensus among scientists on methods for estimating the effects of radiation on ecological resources such as plant or animal life, but since human health effects for all the accidents analyzed are small and most plants and animals are not thought to be more sensitive to radiation than human beings, the small impacts on human health provide an indication that the impacts on animal and plant species in the area would also be small for an alternative which would relocate the Expended Core Facility to the Oak Ridge Reservation. Similarly, since the areas which might be contaminated to measurable levels by chemicals or radioactive material during the hypothetical accidents would be relatively small, effects on the ecology should be limited to small areas. As previously stated, there are no endangered or threatened species unique to the area surrounding the location considered for an Expended Core Facility at the Oak Ridge Reservation, so an accident would not be expected to result in destruction of any species. The effects of accidents related to any of the alternatives and any cleanup which might be performed would be localized within a small area which would extend only a relatively short distance from the Expended Core Facility and thus would not be expected to appreciably affect the potential for survival of endangered or threatened species in the vicinity. Based on these considerations, evaluation of the impacts of accidents on ecological resources does not help to distinguish among alternatives.

5.5.14.4 Effects of Accidents on Environmental Justice Due to Naval Spent Nuclear Fuel

Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from facility or transportation accidents associated with the management of naval spent nuclear fuel at the ORR would be small under any of the alternatives considered. For example, it is unlikely that a single additional fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to an accident for any of the alternatives considered would present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects from accidents associated with the management of naval spent nuclear fuel would be expected for any particular segment of the population, minorities and low-income groups included.

To place the impacts on environmental justice in perspective, the risk from hypothetical accidents associated with naval spent nuclear fuel examination under any of the alternatives considered would amount to less than one additional fatality per year in the entire population. For comparison, in 1990 there were approximately 40,000 traffic fatalities in the United States population and there were about 7,400 deaths caused by traffic accidents among people of color in the U. S. Even if all of the additional cancer deaths associated with an accident involving any of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would experience less than one additional fatal cancer per year. The same conclusion can be drawn for low-income groups.

5.5.15 Waste Management

During Oak Ridge ECF operations, non-radioactive and non-hazardous waste and hazardous waste would be generated in quantities similar to those for the ECF at INEL. Solid sanitary and industrial wastes would be disposed of at an on-site landfill. Hazardous solid wastes would be contained at their point of generation and transported off-site to an approved disposal facility. Waste management practices for these wastes would produce no identifiable impact on public health or safety of the environment.

Operation of the ECF at ORR would generate the same quantities of radioactive low-level waste, transuranic waste, and mixed wastes as the ECF at INEL. Low-level waste generated by the Oak Ridge ECF would be stored on-site pending a future disposal action. The 425 cubic meters (556 cubic yards) of low-level waste generated annually by the ECF at INEL represents a small fraction of the low-level waste managed at ORR. No high-level waste would be generated.

Less than 0.0001 cubic meter of transuranic waste per year is generated by current ECF operations at the INEL. Any transuranic waste generated by the Oak Ridge ECF would be a very small fraction of the transuranic waste at ORR and would not impact planned waste handling operations.
Much of the newly generated and retrievably stored transuranic waste at ORR will be treated and certified for eventual disposal at the DOE Waste Isolation Pilot Project.

Any mixed waste generated by Oak Ridge ECF operations would be stored on-site pending a future disposal action. This would represent a very small fraction of the mixed waste at ORR from past and ongoing operations requiring disposition.

5.5.16 Cumulative Impacts

Up to this point, Section 5.5 has discussed the potential environmental consequences of constructing and operating the ECF at the ORR in terms of annual impacts (i.e., radiological doses and health effects, accident risks, and quantities of wastes that would be generated during operations) based on the maximum expected annual workload of the ECF. To determine the potential consequences for 40 years of ECF operation (from 1995 to 2035), an evaluation of the accumulated environmental consequences and risks of constructing and operating the Oak Ridge ECF was performed.

5.5.16.1 Radiological Cumulative Impacts. Operation of the Oak Ridge ECF would not result

in discharges of radioactive liquids; therefore, there would be no changes to the surface or ground water as a result of normal ECF operations. There would be small quantities of radioactivity in the air released from ECF which would contribute to the cumulative air quality impacts.

The Oak Ridge Reservation has not been used for naval spent nuclear fuel operations in the past. Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

The annual radiological impacts associated with the alternatives where naval spent nuclear fuel would be inspected or stored at ORR are very small and are described in Section 5.5.12, with the detailed results of analyses provided in Attachment F. In order to calculate cumulative impacts for the period between 1995 and 2035, the annual radiological impacts associated with each location and alternative were summed over 40 years. The results of this summation are tabulated in Tables 3-5 and 3-6 of Section 3.

The cumulative transportation impacts for the population groups from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated and are very small. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A and summarized in Section 3.7.4.

The total exposure to the general public from transportation and from Oak Ridge ECF operations would be approximately 15 person-rem. This means that there might be 0.0075 fatal cancers from these operations over the entire 40-year period evaluated. The exposure to the maximally exposed off-site individual would be 4 millirem from 40 years of Oak Ridge ECF operation. The corresponding risk of a cancer fatality to the maximally exposed off-site individual is 2.0 x 10-6 during his or her lifetime. A worker at the Oak Ridge ECF site located 100 meters from the facility would receive less than 5 millirem over 40 years of Oak Ridge ECF operation, which corresponds to a 1.9 x 10-6 risk of fatal cancer during the worker's lifetime. These exposures and cancer risks are as a result of ECF operations only. The exposures and risks corresponding to site-wide operations (including ECF) are discussed in Volume 1, Chapter 5. Analyses of hypothetical accidents which might occur as a result of these alternatives show that the risk of cancer fatalities is small. The impacts associated with transportation of naval spent nuclear fuel for all of the alternatives considered would be similarly low.

Cumulative impacts due to radioactive waste generation are expected to be minimal. Approximately 425 cubic meters (556 cubic yards) of low-level waste are expected to be generated annually by the Oak Ridge ECF over the next 40 years. This is not expected to affect the ORR waste management program. Very little transuranic waste or mixed waste and no high-level waste will be generated from Oak Ridge ECF operations.

No contribution to cumulative impacts from accidents involving naval spent nuclear fuel has been included in the analyses presented in this Environmental Impact Statement because there has never been a nuclear reactor accident, criticality accident, transportation accident, or any release of radioactivity which had a significant effect on the environment.

5.5.16.2 Non-radiological Cumulative Impacts. The cumulative socioeconomic impacts

associated with constructing and operating the Oak Ridge ECF are expected to be minor. The Oak Ridge Reservation employs over 17,000 people. In the past, no employment at the ORR has been associated with naval spent nuclear fuel operations. Oak Ridge ECF operations would provide long-term employment for 500 people at the ORR. The peak number of additional jobs created at the ORR in any given year would be approximately 1050, which includes both construction and operations workers during the peak of the Oak Ridge ECF construction effort. Considering that the labor force in the region of influence consists of over 292,000 people, the additional number of jobs added from the construction and operation of the Oak Ridge ECF would be expected to have only a minor socioeconomic impact in the Oak Ridge area.

Construction and operation of the Oak Ridge ECF are not expected to result in any discernible impacts relative to cumulative non-radiological emissions. Construction of the ECF is sufficiently remote and removed from the nearest ORR boundaries such that concentrations of fugitive emissions from construction would be well below applicable standards, as discussed in Section F.4 of Attachment F. Current operations at the Oak Ridge Reservation are in compliance with Title 40, Code of Federal Regulations, Part 61, "National Emission Standards for Hazardous Air Pollutants." Cumulative air emissions would not threaten to exceed any applicable air quality requirement or regulation, either federal, state, or local in radiological and non-radiological categories.

The withdrawal of surface water for ECF construction and operation at the ORR would be a small percentage of existing withdrawals and well within the cumulative capabilities of the respective water resources. Discharges of ECF non-radioactive and non-hazardous liquid effluents at the ORR would have no measurable impact on water quality or aquatic ecology.

Minimal cumulative land use impacts would be expected to occur as a result of the construction of a new ECF. The land that would be dedicated for this purpose is on existing federal property. The use of this land would not result in the need for additional land to be added to the federally owned property in the foreseeable future. The Oak Ridge Reservation occupies an area of approximately 140 square kilometers (54 square miles) with only about 8% of the land occupied by the Y-12 Plant, K-25 Site, and Oak Ridge National Laboratory. No land area at the Oak Ridge Reservation has been affected by past operations involving naval spent nuclear fuel. Construction of the Oak Ridge ECF would affect 30 acres of land. This is less than 0.09% of the total Oak Ridge Reservation land area.

The cumulative impacts associated with non-radiological waste management are also expected to be small. The volume of hazardous waste produced by ECF has not been calculated; however, considering the nature of the work associated with ECF, the amount of hazardous waste produced would have a small effect on the cumulative impacts associated with this waste. The volume of municipal solid wastes and sanitary wastes which would be generated is expected to be proportional to the number of additional workers added, and this small incremental increase would not be discernible. The amount of non-radiological wastes generated would not introduce any changes to the site's waste management practices and would not impose any additional stress on the capacity of on-site or off-site waste disposal or treatment facilities. Therefore, any cumulative impacts associated with the generation and disposal of additional wastes would be very small. There are no current environmental problems associated with these types of wastes.

5.5.17 Unavoidable Adverse Effects

Construction of an ECF at ORR would directly affect about 30 acres of land area. Site preparation for construction would disturb areas of natural vegetation cover which primarily include oak/hickory forest land. The direct loss of terrestrial habitat would be minimized to the extent practical.

Construction of the Oak Ridge ECF would also generate liquid effluents, atmospheric emissions, and solid wastes typical of those for construction of a major industrial facility. All effluents and emissions would be below applicable environmental requirements and would not be expected to result in any major adverse impacts.

During Oak Ridge ECF operations, non-radioactive and non-hazardous waste and hazardous waste would be generated in quantities similar to those discussed for the INEL. Solid sanitary and industrial wastes would be disposed of in an ORR landfill. Hazardous wastes would be contained at their point of generation and transported off-site to an approved disposal facility. The amount of hazardous waste generated by Oak Ridge ECF operations would be small in comparison to the amount of hazardous waste that is generated at the ORR. No discernible differences from normal hazardous waste management at the ORR would result from this strategy.

During Oak Ridge ECF operations, unavoidable radiation exposures would include occupational exposures and exposures to the public from normal atmospheric emissions of radioactive materials that would be small compared to criteria contained in 40CFR Part 61.92 and DOE Order 5480.1B. Sanitary waste and service waste liquid discharges would be below applicable environmental standards. Solid wastes generated during operations, including transuranic, low-level, hazardous, and mixed wastes, would result in small increases in potential exposures to radioactive and hazardous materials.

Construction and operation of the Oak Ridge ECF would not require the use or consumption of scarce resources. Expected surface water withdrawals during construction and operation would represent small incremental increases in the amount of water being withdrawn by ongoing ORR operations. In general, the unavoidable adverse impacts would be few and limited, and none have been identified that would have a detectable effect on public health and safety. The difference in the impacts between the ECF alternative at ORR and the other DOE sites (INEL, Savannah River, Hanford, Nevada Test Site) is not discernible.

5.5.18 Irreversible and Irretrievable Commitments of Resources

During operation of the Oak Ridge ECF, additional fuel would be burned to supply steam for heat. The fuel is not in short supply. The water to be used for the Oak Ridge ECF would be withdrawn from the Clinch River and would be a small amount. No new water intake structure would be required, and no observed impacts have resulted from previous withdrawals. Total consumption of water attributable to water pool operations and consumption of potable water by operations personnel represent less than one-thousandth of a percent of the Clinch River average annual flow.

The total cost of locating a new ECF at Oak Ridge is approximately $3.5 billion. This cost represents the total cumulative cost over the 40-year period and includes construction and operation costs of the new ECF as well as the cost associated with shutting down the ECF at INEL. Refer to Section 3.7 for a comparison of the total cumulative costs among alternatives.

As is the case with the ECF at INEL, construction and operation of the ECF at ORR would not require the use or consumption of scarce resources.

5.6 NEVADA TEST SITE

5.6.1 Overview of Environmental Impacts

The following sections discuss the potential environmental consequences that would occur if a replacement for the Expended Core Facility (ECF) at the Idaho National Engineering Laboratory (INEL) were constructed and operated at the Department of Energy's Nevada Test Site (NTS). This facility will be referred to as the Nevada ECF. The affected environment for the proposed site, depicted on Figure 4.6-1, is discussed briefly in Section 4.6 and in greater detail in Volume 1, Appendix F.

The environmental consequences of locating and operating the ECF at NTS are based on the same radiological source terms for normal and accidental releases and the estimated atmospheric emissions, liquid effluent, and solid wastes discussed in Section 5.2 for the ECF at INEL. The environmental consequences of locating and operating the Nevada ECF would be similar to those for the ECF at INEL, and none would be large.

5.6.2 Land Use

Over 40.5 square kilometers (10,000 acres) of land exists in the area being considered as a location for the proposed Nevada ECF. This is in the same general area being considered for the proposed spent nuclear fuel storage facility discussed in Volume 1, Appendix F. Construction of an ECF at NTS would directly affect about 30 acres of land. This would result in only a minimal reduction in the available land base of the NTS. Located next to Mercury Highway, the proposed area would support construction and maintenance of an ECF, railcar holding facilities, and necessary support facilities. The ECF facilities would be compatible with all existing and presently foreseeable NTS facilities. The affected land area is small compared to the entire NTS. Native American rights and interests would not be modified by construction or operations associated with any of the alternatives considered.

5.6.3 Socioeconomics

The potential socioeconomic impacts associated with construction of the Nevada ECF are expected to be equal to or less than those associated with the original ECF construction at the INEL because (1) a large movement of construction workers from other areas would not be expected for the Nevada ECF construction due to the availability of construction craft workers in the Las Vegas area; and (2) the counties surrounding the NTS have a population adequate to absorb any temporary relocation of construction personnel.

Table 5.6-1 provides a summary of the direct jobs which would be required for the construction and operation of the Nevada ECF during the 10-year period immediately after the Record of Decision. The greatest number of direct jobs would occur in 1999 during the peak of the construction phase. Estimates of the indirect jobs created as well as the effect on area population are included in Section 5.5.6 of Volume 1 as part of either the Regionalization or Centralization at the Nevada Test Site alternatives.

Table 5.6-1. Summary of direct jobs due to the Nevada ECF.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Direct Jobs	20	20	476	825	1033	894	850	500	500	500

During the Nevada ECF construction period, operations personnel would be hired so that at the end of the construction period, most of the operations workers would be employed. The percentage of operations workers expected to move into the area from other areas varies based on skill requirements. Overall, approximately 20 percent are estimated to move into the NTS area. The Las Vegas Metropolitan Service Area, which constitutes the major portion of the population in the region of influence, had a 1990 population of 735,000 and an estimated population of 900,000 as of August 1993.

The Nevada ECF operation would require essentially the same number of operations personnel (500) as at the INEL. This would represent a relatively small percentage of the total NTS work force. Given the 20-percent estimate for immigration and an average family size of 2.6 persons per household for operations personnel moving into the area, the expected population increase attributable to the operating personnel would be 260 persons.

Given the small percentage of population increase attributable to Nevada ECF operations in relation to normal population increases in the NTS region, no major adverse impacts to local government services and community infrastructures are expected. The economic benefits to the NTS region are expected to be similar to those for the INEL region.

5.6.4 Cultural Resources

Construction at the site considered for the Nevada ECF would not impact any known archaeological or Native American sites. Procedures which comply with all applicable laws and regulations would be implemented to protect previously undetected archaeological and cultural sites.

5.6.5 Aesthetic and Scenic Resources

The construction of the Nevada ECF would directly affect approximately 30 acres of land. As a result of its location and industrial characteristics, there is essentially no aesthetic or scenic impact since the site would not be visible to the public.

5.6.6 Geology

5.6.6.1 General Geology. The local geology of the NTS region has been impacted as a result of

past nuclear testing. This impact has been in the form of surface faulting. Because construction and operation of the Nevada ECF would not produce forces near the magnitude of those produced from past nuclear tests, it is highly unlikely that this activity would cause additional faulting.

5.6.6.2 Geologic Resources. Precious metals may exist in certain carbonate rocks and volcanic

or sedimentary rocks at the NTS. The Nevada ECF would not be located within a mining district and the site will likely remain closed to mining operations so the impact to any precious metal deposits that may exist at the NTS will not change if the proposed facility is sited there.

5.6.7 Air Resources

Minor short-term emissions of fugitive dust and exhaust from heavy equipment would be possible during Nevada ECF construction. The use of toxic chemicals during ECF normal operations would be controlled such that the exposure levels of workers and the public would be negligible. Airborne emissions from normal operations would include the combustion gases from the boiler house, where fuel would be burned to make steam for space heating. Emergency diesel generators, which would be provided for safety, would be operated periodically for test purposes and release exhaust fumes to the atmosphere. These emissions would not have any detectable environmental consequence.

The airborne releases of radioactivity for the ECF at NTS would be the same as for the ECF at INEL described in Section 5.2. The airborne release would result in no measurable exposure to on-site personnel or the general population. Details of the analyses supporting this conclusion are provided in Attachment F.

5.6.8 Water Resources

5.6.8.1 Surface Water. As stated in Section 4.6.8, with the exception of short periods of runoff

from spring discharges, there is no perennial surface water at the NTS. As such, the daily water supply required to operate the Nevada ECF could not be obtained from local surface waters. In fact, the NTS currently derives its complete water supply from the groundwater aquifers. Therefore, the construction and operation of the Nevada ECF would have no impact on the quantity and quality of surface water in the area.

There are no National Pollutant Discharge Elimination System permits for the NTS, as there are no wastewater discharges to on-site and off-site surface waters. NTS wastewaters are discharged to sewage lagoons. Therefore, all wastewaters associated with the construction and operation of the Nevada ECF would likely be discharged into the on-site lagoon system along with the other wastewaters generated at the NTS. Thus, surface water quantity and quality in the NTS area would not be expected to be impacted.

5.6.8.2 Groundwater. The NTS currently extracts groundwater from aquifers within two

hydrographic subbasins: Alkali Flat-Furnace Creek Ranch and Ash Meadows. These subbasins, along with their specific hydrographic areas and NTS well locations, are described in Section 5.8 of Volume 1, Appendix F. The 2.5 million gallons per year additional withdrawal of water from these aquifers required for operation of an ECF represents less than a 3-percent increase over the present rate at which water is withdrawn for use in Area 6 and less than 0.5 percent of the total NTS usage rate.

5.6.9 Ecological Resources

5.6.9.1 Terrestrial Ecology. During construction and operation of the Nevada ECF, all effluent

and emissions would comply with regulatory standards and are not expected to have an impact on the area wildlife. Operation of the Nevada ECF should result in less noise and traffic than the construction phase, and no effects on terrestrial ecology are expected from Nevada ECF operations.

5.6.9.2 Wetlands. National Wetland Inventory maps of the NTS have not been prepared, nor

have wetlands been delineated on the site. However, available information indicates that wetlands on the NTS are limited in distribution and extent. Small areas of wetlands could be present in or on the margins of the surface drainages, playas, and reservoirs on the NTS. It is expected that construction and operation of the Nevada ECF would have negligible impact on any wetlands.

5.6.9.3 Aquatic Ecology. Because there would be no discharge of radioactive or hazardous liquid

effluent from Nevada ECF operation, these operations are expected to have no effect on the aquatic ecology.

5.6.9.4 Endangered and Threatened Species. The endangered and threatened species are

described in Section 4.6.9. The desert tortoise is the only federally listed species that could be affected by the construction of an ECF facility. Forty-five percent of the total known desert tortoise habitat is located in the Yucca Mountains. The area that could be affected directly by the proposed ECF are Frenchman Flat and the southern bajada of Control Point Hills.

Construction and maintenance of roads, utility and communication lines, buildings, water pipelines, sewage lagoons, and other facilities could result in harm or harassment of desert tortoises and loss of habitat. Tortoises could become injured by falling into open trenches or other temporary construction excavations and might not be able to escape. They could become submerged in water storage ponds, wastewater lagoons, and other impoundments not fenced to exclude them.

5.6.10 Noise

Noises generated on the NTS do not propagate off-site at levels that impact the general population. Noise increases outside the NTS due to the Nevada ECF would be limited to those produced by truck, car, and train traffic on roads and railroads approaching the NTS. These increases would not be large enough to be objectionable to the areas bordering the roads and railroads.

5.6.11 Traffic and Transportation

Traffic and transportation would increase in the area if an ECF is constructed and operated at the NTS. The additional traffic would mainly be due to increased commuter traffic from construction workers and 500 operations workers as well as traffic from material shipments during the Nevada ECF construction.

If the Nevada ECF were established, naval spent nuclear fuel would be routinely transported to the site in certified shipping containers. Various types of wastes generated at the facility would be dispositioned on-site and off-site. Following examination, most of the naval spent nuclear fuel would be transferred to the spent fuel storage location on the NTS until the time that permanent geologic storage becomes available.

5.6.12 Occupational and Public Health and Safety

The health and safety assessment of normal operations at the Nevada ECF was based on handling and examination of spent nuclear fuel either in a water pool or in a dry cell. These are the same methods of spent nuclear fuel handling that have been employed or seriously considered for use at the ECF at INEL. The normal operational impacts associated with the Nevada ECF would be similar to those for the ECF at INEL. The following sections describe the non-radiological and radiological impacts associated with the ECF at NTS (refer to Section 5.2 for the ECF at INEL impacts).

5.6.12.1 Occupational Health and Safety. Projections of the number of occupational accidents

that might occur during construction and operation of naval spent nuclear fuel storage and examination facilities have been made for each alternative. These projections are presented in Attachment F. Based on the results of these projections, it is concluded that the number of occupational fatalities and injuries or illnesses for construction activities and storage and examination operations would be very small for any alternative.

During Nevada ECF construction, workers are not expected to experience elevated background levels of radiation resulting from on-going NTS operations. The gamma radiation measured near the proposed Nevada ECF site is similar to the radiation levels measured off-site in the NTS area. The potential exposure to a construction worker from inhalation of radionuclides released to the atmosphere from previous and current NTS operations is expected to be small compared to the external exposure. The exposure received by a construction worker would be well below the naval and Department of Energy (DOE) standard of 5000 millirem per year for occupationally related whole-body and internal exposures.

During operation of the Nevada ECF, NTS personnel would be exposed to routine atmospheric emissions of radioactivity and might be exposed to potential emissions from accidents. The Nevada ECF site is located approximately 3 miles from the Radioactive Waste Management Facility, which is the nearest existing NTS facility. As shown in Attachment F, no measurable exposure would be received by these collocated workers from normal Nevada ECF operations. Exposures received by radiation workers from normal operation of the ECF at NTS are expected to be similar to the exposures currently received by workers from normal operation of the ECF at INEL, discussed in Section 5.2.12.

Exposures, injuries, and potential fatalities to workers at the Nevada ECF could also occur as a result of accidents during ECF operations. However, the safety record of the ECF at INEL is very good, and similar safe working conditions could be established at the new facility.

5.6.12.2 Public Health and Safety. The impacts of normal operation of the Nevada ECF would

be similar to those for the ECF at INEL. Normal radiological releases to the atmosphere and the quantities of radioactive and hazardous wastes that would be generated would not differ from those previously discussed for the INEL. However, the location of the project relative to the surrounding NTS population and the distances to facilities that would be involved in routine shipments of material would result in differences in potential environmental consequences. Described below are the impacts to the public associated with operation of the ECF at NTS (refer to Section 5.2.12 for the ECF at INEL impacts).

Assessment of the normal operations of the Nevada ECF involved handling and examination of spent fuel either in a water pool or in a dry cell. For both cases, the potential annual exposures were estimated for five different types of people: a worker at the Nevada ECF site located 100 meters from the release point, the hypothetical maximally exposed collocated worker on the NTS site, the hypothetical maximally exposed off-site individual, an individual at the nearest public access, and the population within 80 kilometers (50 miles) of the Nevada ECF site. Three pathways were included in the analysis: airborne, waterborne, and direct radiation, as applicable.

The results indicate that handling and examination of spent fuel either in a water pool or in a dry cell would be satisfactory for normal operations since the exposure is so low. The analysis shows that the exposure to all the individuals considered (workers, collocated workers, and off-site individuals) from Nevada ECF operations would be much less than one millirem per year. For perspective, it could be stated that one member of the entire population might experience a fatal cancer due to Nevada ECF operations if operations continued for over 11 million years. A description of the analysis methods and more detailed results are provided in Attachment F. The impacts from normal operations for all alternatives are summarized in Section 3.7.

The radiological and non-radiological health effects associated with the incident-free transportation of naval spent nuclear fuel and test specimens have been assessed for the general population, transportation workers, and hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancers as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. The details of the transportation analysis are provided in Attachment A.

5.6.12.3 Incident-free Occupational and Public Health and Safety Effects on Environ-

mental Justice Due to Naval Spent Nuclear Fuel Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from normal operations associated with the examination of naval spent nuclear fuel at the NTS would be small under any of the alternatives considered. For example, it is unlikely that a single fatal cancer would occur as a result of activities associated with naval spent nuclear fuel examination under any alternative. Since the potential impacts due to normal operations or accident conditions for any of the alternatives considered present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is true for normal operations because the effects of routine operations are so small. It is also true for accident conditions because the consequences of any accident would depend on the random conditions at the time it occurred, and the wind directions at the NTS do not display any strongly dominant direction. Similarly, the conclusion is not affected by concerns related to subsistence consumption of fish or game because of the very small impacts associated with examination of naval spent nuclear fuel.

To place the impacts on environmental justice in perspective, the risk associated with routine operations for naval spent nuclear fuel examination under any of the alternatives considered would be less than one fatality per year for the entire population. For comparison, in 1990 there were approximately 510,000 cancer deaths in the United States population and there were about 64,000 cancer deaths among people of color in the U. S. Even if all of the impacts associated with one of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would be unlikely to experience a single additional cancer fatality in any year. Therefore, the cancer risk for that population from naval spent nuclear fuel management would not constitute a disproportionately high and adverse impact on human health or the environment. The same conclusion can be drawn for low-income groups.

5.6.13 Utilities and Energy

Heating, ventilation, and electrical systems appropriate to the needs of the Nevada ECF for suitable working environments and to properly filter and exhaust the airborne discharges to the atmosphere are estimated to require approximately 10,000 MWh per year for normal operations. This would represent about a 4-percent increase in NTS electrical consumption and may require transmission line upgrades. Emergency diesel electrical generators would provide 350 kW for crucial facility services during power outages.

5.6.14 Facility and Transportation Accidents

The differences in the potential consequences and risks of accidents at the ECF at NTS compared to the ECF at INEL are related to the meteorological transport of released material, the population exposure, and the distance of transport. The following sections address the potential accident consequences and risks associated with locating an ECF at the NTS.

5.6.14.1 Facility Accidents. A number of hypothetical accidents were evaluated for the Nevada

ECF. These included radiological accidents involving naval spent nuclear fuel during water pool storage, dry storage, and dry cell operations, as well as accidents involving toxic chemicals used at ECF. Calculations of the cancer fatalities which might occur as a result of all the postulated accidents are provided in Attachment F. A comparison of the accident consequences for all alternatives is provided in Section 3.7.

The difference in the calculated consequences for accidents at the Nevada ECF compared to the ECF at INEL is that the exposure received by the entire population would be less at the Nevada ECF due to a different population distribution within an 80-kilometer (50-mile) radius of the site. The most limiting of the postulated accidents for the Nevada ECF would be an airplane crash into a dry cell facility. The exposure to the entire population from this accident is calculated to cause 0.18 cancer fatalities over 50 years, as described in Attachment F.

The exposures to collocated workers following all accidents are well below the naval and DOE standard of 5 rem per year for occupational exposure. However, exposures to the worker located at a Nevada ECF site 100 meters from the radiation release point could exceed this standard following an accident resulting in an inadvertent criticality or an airplane crash into a dry cell.

Effects from accidents at the Nevada ECF involving toxic chemicals are similar to those described in Section 5.2.14 for the existing ECF at INEL. Due to the amount and types of chemicals stored at the ECF site, toxic chemicals do not pose a risk to the public following any of the postulated accidents. However, following the maximum foreseeable accident analyzed (a fire transient), a number of toxic chemicals would exceed Emergency Response Planning Guideline (ERPG) values for workers on the Nevada ECF site. For the maximum off-site individual, ERPG-2 values for the toxic chemicals are not exceeded under either 50% meteorology or 95% meteorology conditions. The concentrations of toxic chemicals as well as a summary of the analysis methods are provided in Attachment F.

5.6.14.2 Transportation Accidents. The health effects associated with accidents during

shipments of naval spent nuclear fuel and test specimens have been assessed for the general population and hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any health effects as a result of naval spent nuclear fuel and test specimen shipments since the risk estimates are much less than one fatal cancer or detrimental health effect for each alternative. However, the most severe accident, with a likelihood of occurrence greater than 1 x 10-7 events per year, is estimated to result in a maximum of 2.1 fatalities. The details of the transportation analysis are provided in Attachment A.

5.6.14.3 Other Impacts of Accidents. In addition to the possible human health effects

associated with facility or transportation accidents described in the preceding sections, other effects such as the impacts on socioeconomics and land use in the area and the costs of cleanup have been estimated in order to develop a perspective and to evaluate potential differences among alternatives.
The analyses described in Attachment F showed that for the most severe hypothetical accidents, an area of between about 8 acres extending about 1/4 mile downwind (for an accidental criticality) and approximately 210 acres extending about 1 1/4 mile downwind (for a large airplane crash into the fuel examination facility) might be contaminated to the point where exposure could exceed 100 millirem per year. Beyond these distances, the exposure would be less than 100 millirem, the Nuclear Regulatory Commission's standard for protection of the general population from radiation. The area affected by the hypothetical accidents would not extend beyond the boundaries of the Nevada Test Site. Persons who work at locations within this area might be prevented from going to their jobs at the federally owned facilities until measures had been taken to reduce the potential for exposure.

An accident might result in short-term restrictions on access to a relatively small area, but it would not be expected to produce any enduring impacts on cultural or similar resources or concerns such as Native American rights or interests, partially because the area involved would be small and partly because all remedial actions would be conducted in a careful, controlled manner in full compliance with applicable laws and regulations. The area would vary only slightly among the alternatives. Overall, the risks are small so these considerations do not assist in distinguishing among alternatives.

Facility or transportation accidents associated with an Expended Core Facility at the Nevada Test Site would not have an appreciable effect on the ecology of the area, considering the potential for human health effects and the amount of land which might be affected, as described in earlier parts of this section. There is little consensus among scientists on methods for estimating the effects of radiation on ecological resources such as plant or animal life, but since human health effects for all the accidents analyzed are small and most plants and animals are not thought to be more sensitive to radiation than human beings, the small impacts on human health provide an indication that the impacts on animal and plant species in the area would also be small for an alternative which would relocate the Expended Core Facility to the Nevada Test Site. Similarly, since the areas which might be contaminated to measurable levels by chemicals or radioactive material during the hypothetical accidents would be relatively small, effects on the ecology should be limited to small areas. As previously stated, there are no endangered or threatened species unique to the area surrounding the location considered for an Expended Core Facility at the Nevada Test Site, so an accident would not be expected to result in destruction of any species. The effects of accidents related to any of the alternatives and any cleanup which might be performed would be localized within a small area which would extend only a relatively short distance from the relocated Expended Core Facility and thus would not be expected to appreciably affect the survival potential of endangered or threatened species in the vicinity. Based on these considerations, evaluation of the impacts of accidents on ecological resources does not help to distinguish among alternatives.

5.6.14.4 Effects of Accidents on Environmental Justice Due to Naval Spent Nuclear Fuel

Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from facility or transportation accidents associated with the management of naval spent nuclear fuel at the NTS would be small under any of the alternatives considered. For example, it is unlikely that a single additional fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to an accident for any of the alternatives considered would present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects from accidents associated with the management of naval spent nuclear fuel would be expected for any particular segment of the population, minorities and low-income groups included.

To place the impacts on environmental justice in perspective, the risk from hypothetical accidents associated with naval spent nuclear fuel examination under any of the alternatives considered would amount to less than one additional fatality per year in the entire population. For comparison, in 1990 there were approximately 40,000 traffic fatalities in the United States population and there were about 7,400 deaths caused by traffic accidents among people of color in the U. S. Even if all of the additional cancer deaths associated with an accident involving any of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would experience less than one additional fatal cancer per year. The same conclusion can be drawn for low-income groups.

5.6.15 Waste Management

During Nevada ECF operation, non-radioactive and non-hazardous solid waste and hazardous solid waste would be generated in quantities similar to those for the ECF at INEL. These wastes would be managed in a manner identical to that for the ECF at INEL (i.e., non-hazardous, non-radioactive solid wastes would be disposed of at a sanitary landfill and hazardous solid wastes would be contained at their point of generation and transported off-site to an approved disposal facility). Waste management practices for these wastes would produce no identifiable impact on public health and safety of the environment.

Operation of the ECF at NTS would generate the same quantities of low-level waste, transuranic waste, and mixed wastes as the ECF at INEL. Low-level waste generated by Nevada ECF would be disposed of at the NTS. The 425 cubic meters (556 cubic yards) of low-level waste generated annually by the ECF at INEL represents a small fraction of the low-level waste managed at the NTS and would not impact planned disposal operations. No high-level waste would be generated.

Less than 0.0001 cubic meter of transuranic waste per year is generated by current ECF operations at the INEL. Any transuranic waste generated by the Nevada ECF would be added to the Nevada Test Site's transuranic waste storage cell, and would not impact planned waste handling operations. Any mixed wastes generated by Nevada ECF operation would be stored on-site pending a future disposal action.

5.6.16 Cumulative Impacts

Up to this point, Section 5.6 has discussed the potential environmental consequences of constructing and operating the ECF Project at the NTS in terms of annual impacts (i.e., radiological doses and health effects, accident risks, and quantities of wastes that would be generated during operations) based on the maximum expected annual workload of the ECF. To determine the potential consequences for 40 years of ECF operation (from 1995 to 2035), an evaluation of the accumulated environmental consequences and risks of constructing and operating the Nevada ECF was performed.

5.6.16.1 Radiological Cumulative Impacts. The Nevada Test Site has not been used for naval

spent nuclear fuel operations in the past. Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

Operation of the Nevada ECF will not result in discharges of radioactive liquids; therefore, there would be no changes to the surface or ground water as a result of normal operations for any alternative. There will be small quantities of radioactivity in the air released from ECF which would contribute to the cumulative air quality impacts.

The annual radiological impacts associated with the alternatives where naval spent nuclear fuel would be inspected or stored at the NTS are very small and are described in Section 5.6.12, with the detailed results of analyses provided in Attachment F. In order to calculate cumulative impacts for the period between 1995 and 2035, the annual radiological impacts associated with each location and alternative were summed over 40 years. The results of this summation are tabulated in Tables 3-5 and 3-6 of Section 3.

The cumulative transportation impacts for the population groups from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated and are very small. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A and summarized in Section 3.7.4.

The total exposure (from operations and transportation) to the general public from Nevada ECF operation would be approximately 6 person-rem. This means that there would be less than 3 x 10-3 fatal cancers from these operations over the entire 40-year period evaluated. The exposure to the maximally exposed off-site individual would be less than 1 millirem from 40 years of Nevada Test Site ECF operation. The corresponding risk of a cancer fatality to the maximally exposed off-site individual is 6.8 x 10-9 during his or her lifetime. A worker at the Nevada Test Site ECF located 100 meters from the facility would receive less than 2 millirem over 40 years of Nevada Test Site ECF operation, which corresponds to a 7.2 x 10-7 risk of fatal cancer during the worker's lifetime. These exposures and cancer risks are as a result of ECF operations only. The exposures and risks corresponding to site-wide operations (including ECF) are discussed in Volume 1, Chapter 5. Analyses of hypothetical accidents which might occur as a result of these alternatives show that the risk of cancer fatalities is small. The impacts associated with transportation of naval spent nuclear fuel for all of the alternatives considered would be similarly low.

Cumulative impacts due to radioactive waste generation are expected to be minimal. Approximately 425 cubic meters of low-level waste are expected to be generated annually by the Nevada ECF over the subject 40-year period. This is not expected to affect the NTS waste management program. Very little transuranic waste or mixed waste and no high-level waste will be generated from Nevada ECF operations.

No contribution to cumulative impacts from accidents involving naval spent nuclear fuel has been included in the analyses presented in this Environmental Impact Statement because there has never been a nuclear reactor accident, criticality accident, transportation accident, or any release of radioactivity which had a significant effect on the environment.

5.6.16.2 Non-radiological Cumulative Impacts. The cumulative socioeconomic impacts

associated with constructing and operating the Nevada ECF are expected to be minor. The Nevada Test Site currently employs over 8,500 people. In the past, no employment at the NTS has been associated with naval spent nuclear fuel operations. Nevada Test Site ECF operations would provide long-term employment for 500 people at the NTS. The peak number of additional jobs created at the NTS in any given year would be approximately 1050, which includes both construction and operations workers during the peak of the Nevada Test Site ECF construction effort. Considering that the labor force in the region of influence is expected to reach 792,309 people by 2004, the additional number of jobs added from the construction and operation of the Nevada Test Site ECF would be expected to have only a minor socioeconomic impact in the NTS area.

Construction and operation of the Nevada ECF are not expected to result in any discernible impacts relative to cumulative non-radiological emissions. Construction of the ECF is sufficiently remote and removed from the nearest NTS boundaries such that concentrations of fugitive emissions from construction would be well below applicable standards, as discussed in Section F.4 of Attachment F. Current operations at the Nevada Test Site are in compliance with Title 40, Code of Federal Regulations, Part 61, "National Emission Standards for Hazardous Air Pollutants." Cumulative air emissions would not threaten to exceed any applicable air quality requirement or regulation, either federal, state, or local in radiological and non-radiological categories.

Minimal cumulative land use impacts would be expected to occur as a result of the construction of a new ECF. The land that would be dedicated for this purpose is on existing federal property. The use of this land would not result in the need for additional land to be added to the federally owned property in the foreseeable future. The Nevada Test Site occupies an area of approximately 3,500 square kilometers (1,350 square miles) of which only about 0.55% is developed. No land area at the Nevada Test Site has been affected by past operations involving naval spent nuclear fuel. Construction of the Nevada Test Site ECF would affect 30 acres of land. This is less than 0.004% of the total Nevada Test Site land area.

The cumulative impacts associated with non-radiological waste management are also expected to be small. The volume of hazardous waste produced by ECF has not been calculated; however, considering the nature of the work associated with ECF, the amount of hazardous waste produced would have a small effect on the cumulative impacts associated with this waste. The volume of municipal solid wastes and sanitary wastes which would be generated is expected to be proportional to the number of additional workers added, and this small incremental increase would not be discernible. The amount of non-radiological wastes generated would not introduce any changes to the site's waste management practices and would not impose any additional stress on the capacity of on-site or off-site waste disposal or treatment facilities. Therefore, any cumulative impacts associated with the generation and disposal of additional wastes would be very small. There are no current environmental problems associated with these types of wastes.

5.6.17 Unavoidable Adverse Effects

Construction of an ECF at NTS would directly affect about 30 acres of land area. The direct loss of terrestrial habitat would be minimal.

Construction of the Nevada ECF would also generate liquid effluents, atmospheric emissions, and solid wastes typical of those for construction of a major industrial facility. All effluents and emissions would be below applicable environmental requirements and would not be expected to result in any major adverse impacts.

During Nevada ECF operations, non-radioactive and non-hazardous solid waste and hazardous solid waste would be generated in quantities similar to those discussed for the INEL. Non-radioactive and non-hazardous solid waste would be disposed of in the NTS sanitary landfill. Hazardous wastes would be contained at their point of generation and transported off-site to an approved disposal facility. The amount of hazardous waste generated by Nevada ECF operation would be small in comparison to the amount of hazardous waste that is generated and currently in interim storage at the NTS. No discernible differences from normal hazardous waste management at the NTS would result from this strategy.

During Nevada ECF operations, unavoidable radiation exposures would include occupational exposures and exposures to the public from normal atmospheric emissions of radioactive materials that would be minimal compared to criteria contained in 40CFR Part 61.92 and DOE Order 5480.1B. Sanitary waste and service waste liquid discharges would be below applicable environmental standards. Solid wastes generated during operations, including transuranic, low-level, hazardous, and mixed wastes, would result in small increases in potential exposures to radioactive and hazardous materials. Freon emissions would result in a negligible increase in the risk of skin cancer; substitutes will be used when available.

Construction and operation of the Nevada ECF would not require the use or consumption of scarce resources. Expected groundwater withdrawals during construction and operation would represent small incremental increases in the amount of water being withdrawn by ongoing NTS operations. In general, the unavoidable adverse impacts would be few and limited, and none have been identified that would have a detectable effect on public health and safety. The difference in the impacts between the ECF alternative at the NTS and the other DOE sites (INEL, Savannah River, Hanford, Oak Ridge) is not discernible.

5.6.18 Irreversible and Irretrievable Commitments of Resources

During operation of the Nevada ECF, additional fuel would be burned to supply steam for heat. The fuel is not in short supply. The water to be used for the Nevada ECF would be withdrawn from the groundwater aquifers. No new water wells are expected to be required, and no observed impacts have resulted from previous withdrawals. Total consumption of water attributable to water pool operations and consumption of potable water by operating personnel would represent only a small percentage of the supply available by aquifer recharge.

The total cost of locating a new ECF at the Nevada Test Site is approximately $3.5 billion. This cost represents the total cumulative cost over the 40-year period and includes construction and operation costs of the new ECF as well as the cost associated with shutting down the ECF at INEL. Refer to Section 3.7 for a comparison of the total cumulative costs among alternatives.

As is the case with the ECF at INEL, construction and operation of the Nevada ECF would not require the use or consumption of scarce resources.

5.7 RELATIONSHIP BETWEEN SHORT-TERM USE OF THE ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

Implementation of any of the alternatives for the Navy will commit and utilize some environmental resources shortly after the implementation date. In general, up to an additional 30 acres of land could be committed to support naval spent nuclear fuel management activities; it should be noted however that the land at the Naval Reactors Facility at the Idaho National Engineering Laboratory is already committed to this purpose and implementation of the Preferred Alternative would not require the commitment of any additional land. The spent nuclear fuel management activities are expected to require up to 2.5 million gallons of water per year and up to 10,000 megawatt-hours of electrical energy per year depending on the alternative selected. As discussed throughout this Appendix, the normal operations associated with naval spent nuclear fuel management will result in some radioactive releases and releases of some toxic chemicals and other pollutants; however, due to the types of operations involved and the stringent controls that would be in place, these releases would be extremely small and would not affect long-term productivity of any site.

Commitment of these resources is necessary to support long-term safe handling, storage, and examination of naval spent nuclear fuel.

5.8 POTENTIAL MITIGATION MEASURES

As stated earlier, all of the environmental impacts associated with implementation of any of the alternatives would be small. However, measures will be taken to reduce these small effects to the lowest possible levels. Consistent with existing Naval Nuclear Propulsion Program policies and historical practices, actions would be taken to prevent pollution, and to mitigate the impacts of naval spent nuclear fuel management facility construction, operations and potential accidents. These measures are summarized below; additional discussion is provided in Attachment F.

5.8.1 Pollution Prevention

Extensive environmental control programs and procedures are in place at all naval sites in order to minimize any environmental and public safety and health impacts that might result from radiological and non-radiological operations. A summary of some of these controls is provided in the following sections.

5.8.1.1 Radiological Pollution Prevention Actions.

The policy of the U.S. Navy is to reduce to the minimum practicable the amounts of radioactivity released to the environment. This policy is implemented at shipyards and prototype sites through procedures that are consistent with the recommendations of the National Council on Radiation Protection and Measurements and the standards issued by the U.S. Environmental Protection Agency, International Commission on Radiation Protection, International Atomic Energy Agency, National Academy of Science - National Research Council, U.S. Nuclear Regulatory Commission, and U.S. Department of Energy.

The principal source of radioactivity in liquid effluents is trace amounts of corrosion and wear products from reactor plant metal surfaces in contact with reactor cooling water. Concentrations of radioactive fission products are normally not a consideration for waste disposal because these fission products remain within spent nuclear fuel elements, which are not handled as waste. Radioactive liquids that are generated at shipyard and prototype sites are collected in containers, processed to remove most of the radioactivity, and reused rather than intentionally discharged to the environment.

Radiological work facilities are designed to ensure that there are no appreciable discharges of radioactivity in airborne exhausts. Radiological controls are exercised in radiological work facilities to preclude exposure of workers to airborne radioactivity exceeding limits specified in Title 10, Code of Federal Regulations, Chapter 20. These controls include performing work involving radioactive materials inside plastic bags or glove boxes which are completely sealed off from the environment. Air exhausted from radiological work facilities is passed through high efficiency particulate air filters which remove more than 99.9 percent of all particles from air, and is monitored during discharge to verify the effectiveness of the control measures.

Sources of radiation are controlled at shipyards and prototypes. Radiological work facilities are designed to minimize radiation exposure to personnel who perform work in the facility and to ensure that exposure to personnel outside the facility is negligible. Ambient radiation is measured with sensitive devices outside the boundaries of areas where radiological work is performed in order to confirm that radiological operations result in no measurable increase in exposure to the general public.

Shipyards and prototypes are not permitted to dispose of radioactive waste on their sites. All solid radioactive wastes are packaged in strong, tight containers, shielded as necessary, and shipped to burial sites that are either licensed by the U.S. Nuclear Regulatory Commission or a state under agreement with the U.S. Nuclear Regulatory Commission or are authorized for radioactive waste disposal by the U.S. Department of Energy. The volume of waste that is generated and shipped is minimized through use of work procedures that limit the amount of material that becomes contaminated during work on radioactive systems and reactor components. Workers periodically receive training specifically intended to help them minimize the production of radioactive waste.

Personnel who work with radioactive materials receive specific training regarding the potential hazards associated with radioactive materials, the general and specific radiological aspects which he or she might encounter, and his or her responsibility to the Navy and the public for safe handling of radioactive materials. More details regarding the scope of this training are provided in Naval Nuclear Propulsion Program Reports NT-94-2 and NT-94-3 (NNPP 1994b and NNPP 1994c).

5.8.1.2 Non-radiological Pollution Prevention Actions. Naval shipyards and prototype sites

follow applicable federal, state, and local requirements for the prevention of release of non-radiological pollutants to the environment. Procedures are in place at each location that ensure that operations at the shipyard or prototype comply with environmental requirements and that the operations do not have an adverse effect on the workers, the public, and the environment.

Shipyards and prototype sites are subject to regulation under the Clean Air Act. All sites follow Environmental Protection Agency, state, and local regulations regarding air pollution prevention. Permits are secured as required for operation of facilities which might emit criteria, toxic, or hazardous air pollutants. Equipment is designed and operated in order to comply with the National Emission Standards for Hazardous Air Pollutants and National Ambient Air Quality Standards for the region. Procedures are also in place at shipyard and prototype sites to ensure that the facilities comply with federal, state, and local requirements regarding asbestos emissions, open burning, vehicle emissions, and use of ozone depleting substances. When appropriate, air emissions are treated in order to achieve compliance with requirements and to ensure that the emissions will not degrade ambient air quality.

Shipyard and prototype sites also must comply with the requirements of the Clean Water Act. The Navy policy is to reduce or eliminate the need for wastewater treatment by minimizing or eliminating pollutants at the source. Permits are secured as required for all point source discharges to navigable waters and corrective measures are taken to comply with the terms of these permits. For cases where Publicly Owned Treatment Works are used for industrial wastewater discharges, measures are taken by the site to ensure that the discharges are in accordance with federal, state, and local requirements.

Each site has an active program for evaluating equipment and chemicals proposed for purchase to minimize or eliminate environmental, safety, and health hazards. These evaluations also help to minimize the amount of hazardous waste that is generated by ensuring that the types and quantities of hazardous materials procured are kept to a minimum. Each site has an active program to investigate the replacement of toxic or hazardous materials with other materials and, when possible, substitutions are made in order to avoid the use of chemicals that would result in the generation of hazardous waste. The procurement program includes approval by appropriate safety and health organizations at the site. Hazardous wastes and other toxic substances, such as polychlorinated biphenyls, are handled and disposed of in accordance with applicable Environmental Protection Agency, state, and local requirements. Personnel who handle hazardous materials, hazardous wastes, and other potentially hazardous substances receive training regarding the specific hazards of the materials that they are expected to handle and the methods for safely handling those materials. This training is conducted in accordance with applicable requirements such as those mandated by the Occupational Safety and Health Administration, the Department of Transportation, and the Environmental Protection Agency. Non-hazardous solid wastes are handled and disposed of in accordance with applicable federal, state, and local requirements. When practicable and economically feasible, materials are recycled or recovered.

Naval designs also consider the effects of the life-cycle of components, including the ultimate disposal. For example, stainless steel fittings are frequently used in equipment in place of brass or bronze fittings, which contain lead, and which can allow lead to leach out of the metal alloys. Similarly, solvents chosen for naval work in recent years have been selected to avoid volatile substances and complex organic chemicals.

Contingency plans exist at shipyard and prototype sites to respond to all accidental discharges and hazardous substance (radiological and non-radiological) releases. These plans have been developed in accordance with the applicable federal, state, and local requirements and are intended to ensure that workers, the public, and the environment would be protected in the event of an accidental release.

5.8.1.3 Prevention of Mixed Wastes. Mixing of radioactive and chemically hazardous materials

is avoided; compounding the intrinsic hazards of radioactivity with the chemical hazards of other materials creates a complex regulatory and occupational safety and health situation that impairs the execution of the work. For example, hazardous materials which could give rise to hazardous wastes listed under the Resource Conservation and Recovery Act (such as acetone) are precluded from use in radiological work. Other materials such as alcohol are used instead. The success of Program efforts in avoiding the creation of mixed radioactive and hazardous waste is reflected by the fact that in 1993, Program sites, naval shipyards, and Program DOE laboratories and prototypes produced less than 30 m3 of mixed waste and hold a current inventory of less than 100 m3.

5.8.2 Construction

In the event that implementation of an alternative requires construction of a new facility, the location will be selected to avoid impacts on the cultural, archaeological, aesthetic, or scenic resources of the area and to ensure that the rights and interests of Native American or Native Hawaiian groups are not infringed. Ecologically sensitive areas such as those in the vicinity of threatened or endangered species, and sites listed in the National Register of Historical Places would be avoided.

If upon implementation of an alternative, it is determined that construction of a naval spent nuclear fuel management facility would appreciably impact some resources, then actions to minimize those impacts would be taken. These actions could include, but would not be necessarily limited to, items such as: archaeological data collection prior to construction, education of workers about cultural resources and unauthorized artifact collection, involvement of Native Americans or Native Hawaiians in the selection of a mitigation strategy, and memorandums of agreement between the DOE and concerned parties. Preactivity surveys would be conducted to identify any plant or animal species that could be affected. As needed, mitigation measures and recovery plans would be developed; agencies such as the U.S. Fish and Wildlife Services and the Corps of Engineers would be consulted.
The potential for soil erosion could be reduced through methods such as control of storm water runoff, including sediment catch basins. Fugitive dust emissions would be minimized by periodically wetting exposed soils. Traffic concerns could be controlled by widening of roads and traffic demand management. Workers in the construction environment would be protected by the use of hard hats and ear plugs and other safety equipment as needed.

5.8.3 Normal Operations

As has been the policy of the Naval Nuclear Propulsion Program, normal work practices at any naval spent nuclear fuel management facility would be designed to minimize releases and therefore mitigate the impacts on the environment. Releases as a result of normal operations would be minimized through a variety of measures, including: closely controlling the generation of contaminated waste, using total containment devices for certain work that could result in a radioactive release, filtering the ventilation exhaust from radiological facilities, and recycling and treating water used in contaminated systems. All radiological workers at naval facilities are trained in these mitigation principles and in other methods of minimizing radiation exposure. Mitigative measures for the use of toxic or hazardous materials make use of administrative controls, training, and safety equipment to provide personnel protection and emergency response. For personnel protection, controls involve safety review committees for planned activities that establish requirements, safe work permits and procedures, and the use of required clothing such as rubber boots, gloves, face shields, and eye protection that mitigate the effects associated with use of toxic or hazardous materials. Procedures may also require provisions for positioning mitigative devices such as eyewash stations and emergency showers before work is allowed to commence. All of the facilities being evaluated would employ emergency response programs to mitigate impacts of potential toxic chemical accidents to workers and the public.

5.8.4 Accidents

Although a serious accident involving naval spent nuclear fuel is highly unlikely, emergency plans are in place at all nuclear naval facilities to mitigate the impacts of a facility or transportation accident. These plans include activation of emergency control organizations throughout the Naval Nuclear Propulsion Program to provide on-scene response as well as support for the on-scene response team. Realistic training exercises are conducted periodically to ensure that the response organizations maintain a high level of readiness, and to ensure that coordination and communication lines with local authorities and other federal and state agencies are effective. In addition, naval fuel is designed to resist corrosion and damage due to accident conditions; this rugged construction would also have an important mitigative effect on the impacts of an accident involving naval spent nuclear fuel.

Emergency response measures include provisions for immediate response to any emergency at any naval site, identification of the accident conditions, and communications with civil authorities providing radiological data and recommendations for any appropriate protective actions. In the event of an accident involving radioactive or toxic materials, workers in the vicinity of the accident would promptly evacuate the immediate area. This evacuation can typically be accomplished within minutes of the accident and would reduce the hazard to workers.

For members of the general public residing at the site boundary and beyond, action would be taken to prevent the public from exceeding certain limits on exposure to radiation or other hazards if needed. Individuals that reside or work on site, or those that may be traversing the site in a vehicle would be evacuated from the affected area within 2 hours. Security personnel and appropriate local officials at all locations would oversee the removal of residents, workers, and travelers in a safe and efficient manner. Periodic training and evaluation of the emergency response personnel is conducted to ensure that correct actions are taken during an actual casualty. Therefore, exposure of residents, workers, and travelers to any hazard, including the potential for ingestion and inhalation of contamination, would be limited, as much as possible. Upon stabilization of the situation, recovery and remediation actions would be implemented as soon as practicable.

5.9 REFERENCES

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APPENDIX D Naval Spent Nuclear Fuel Management Part B

Department of Energy Programmatic
Spent Nuclear Fuel Management
and
Idaho National Engineering Laborartory
Environmental Restoration and
Waste Management Programs
Final Environmental Impact Statement
Volume 1
Appendix D
Part B
Naval Spent Nuclear Fuel Management
April 1995
U.S. Department of Energy
Office of Environmental Management
Idaho Operations Office

ATTACHMENT A - TRANSPORTATION OF NAVAL SPENT NUCLEAR FUEL

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ATTACHMENT A

TRANSPORTATION OF
NAVAL SPENT NUCLEAR FUEL

A.1 PURPOSE AND SCOPE

This attachment provides an evaluation of the radiological and non-radiological risks associated with the transportation of naval spent nuclear fuel and test specimens that originate from Navy and commercial shipyards, prototypes, and related Department of Energy laboratories. This evaluation covers all past shipments through May 1995 and shipments planned in the 40-year period from June 1995 through the end of 2035. This attachment evaluates the radiological risks associated with the five alternatives described in Section 3.

A.2 BACKGROUND

The transportation of naval spent nuclear fuel and test specimens covered in this attachment falls into the following four categories:

- Shipments of Naval Spent Nuclear Fuel from Shipyards and Prototypes
- Transfers of Naval Spent Nuclear Fuel to Storage Following Examination
- Transfers of Naval Test Specimen Assemblies Between the Examination Facility and the Test Reactor Area
- Shipments of Naval Test Specimens to Examination and Testing Facilities.

Each category is described in more detail below.

A.2.1 Shipments of Naval Spent Nuclear Fuel from Shipyards and Prototypes

Since 1956, spent nuclear fuel has been removed from Navy nuclear-powered ships and prototypes as a routine part of their operational cycle. The spent nuclear fuel has been transported to the Expended Core Facility (ECF) for examination and evaluation. ECF is part of the Naval Reactors Facility (NRF) within the Idaho National Engineering Laboratory (INEL). The examinations of the spent nuclear fuel and irradiated test specimens have provided and will continue to provide engineering data for materials and designs used in technology development for naval nuclear reactors.

In the past, shipments have originated from two prototype sites, nine shipyard locations, and the Shippingport Atomic Power Station (SAPS), located in Shippingport, Pennsylvania. The two prototype locations are the Kenneth A. Kesselring Site (KSO), located in West Milton, New York and the Windsor Site Operation (WSO), located in Windsor, Connecticut. The nine shipyard locations are Newport News Shipbuilding (NNS), located in Newport News, Virginia; the Norfolk Naval Shipyard (NOR), located in Portsmouth, Virginia; the Pearl Harbor Naval Shipyard (PHNS), located in Pearl Harbor, Hawaii; the Portsmouth Naval Shipyard (PNS), located in Kittery, Maine; the Puget Sound Naval Shipyard (PSNS), located in Bremerton, Washington; the Charleston Naval Shipyard (CNS), located in Charleston, South Carolina; the Mare Island Naval Shipyard (MINS), located in Vallejo, California; the Electric Boat Division of General Dynamics (EB), located in Groton, Connecticut, and Ingalls Shipbuilding (INGL), located in Pascagoula, Mississippi. Figure A-1 provides a map of the United States showing the transportation origins for naval spent nuclear fuel. No future shipments from the Electric Boat Division, Ingalls Shipbuilding, and Shippingport Atomic Power Station facilities are planned. The Mare Island Naval Shipyard, Charleston Naval Shipyard, and Windsor Site Operations facilities are being phased out.

The naval spent nuclear fuel has been shipped in M-130, M-140, M-160, and S2W/S2Wa shipping containers. Only the M-130, M-140, and M-160 shipping containers will be used in the future. A detailed description of the shipping containers to be used for naval spent nuclear fuel shipments from shipyards and prototype sites is provided in Section A.4.1.

Figure A-1. Transportation origins for naval spent nuclear fuel.

The naval spent nuclear fuel is primarily shipped by rail. However, for the two prototype sites, rail spurs to the sites are not available. Therefore, the shipping containers are transported by heavy-lift transporter to a nearby commercial rail line where the containers are then transported by rail. For the Pearl Harbor Naval Shipyard, the containers are transported by ship to the Puget Sound Naval Shipyard where the containers are then transported to ECF by rail. Since 1956, 599 containers of naval spent nuclear fuel have been shipped to ECF. An additional 16 containers of spent nuclear fuel were shipped (12 from Shippingport Atomic Power Station to Hanford and 4 from ECF to Hanford); however, these shipments are covered by the DOE historic shipment calculations in Appendix I, Volume 1 of this Environmental Impact Statement. Table A-1 provides a list of these shipments made by year and originating facility.

A.2.2 Transfers of Naval Spent Nuclear Fuel to Storage Following Examination

In the past, following examinations at ECF, the spent nuclear fuel has been prepared and transferred to the Idaho Chemical Processing Plant (ICPP), also located on the INEL. A detailed description of the operations performed in the Expended Core Facility is provided in Attachment B. Naval spent nuclear fuel is currently being held at ICPP until permanent disposition becomes possible.

Since 1956, approximately 5400 transfers of naval spent nuclear fuel have been made from ECF to ICPP in shipping casks transported by truck dedicated to performing only such shipments (exclusive-use). For alternatives involving continued transfers to storage, the transfers would be made in the NFS-100, Peach Bottom, and Large Cell casks, in exclusive-use trucks. A detailed description of the

shipping casks
used for naval spent nuclear fuel transfers to storage is provided in Section A.4.2.

A.2.3 Transfers of Naval Test Specimen Assemblies Between the

Examination Facility and the Test Reactor Area

In addition to naval spent nuclear fuel from ships and prototypes, irradiated test specimen assemblies (fuel and non-fuel) have also been transported to ECF for examination. Test specimens, which
are constructed of plant materials, reactor structural materials, and fuels used in naval reactor

Table A-1. Number of past naval spent nuclear fuel containers shipped to ECF by origin.

	Origin												
Year	EB	SAPS	KSO	MINS	PHNS	PSNS	NNS	PNS	CNS	WSO	NOR	INGL	TOTAL
1957	1												1
1958			1										1
1959	1							1					2
1960													0
1961	1	2	2										5
1962	5			1	1								7
1963		3		1	1								5
1964	2	1	2										5
1965	2	1		2			33	1	2		1		42
1966	4	2		1	1			1		1			10
1967	2		1			2	8	3	3		4		23
1968	2			4		4	2	3	2				17
1969	8		2	3	1	2	4		2				22
1970	4			7		2	32	2	2				49
1971	4			2		8	4	2					20
1972	2			4		2	2		4		1		15
1973	2	1	1	2	1	6	4	2	2				21
1974	2	1		6		6	2	3				2	22
1975	2		1	4	1	4	2		2	1		2	19
1976	4		3	7			2	4	2			2	24
1977				4	1	2	2	2	2			2	15
1978		2		3	1	4	4		2			2	18
1979				1		2			2				5
1980				2		6	4	1	1				14
1981					1		4		3				8
1982					1		6		3				10
1983		3		2		6	4		2	1			18
1984		7			1	6	4	2					20
1985						2	2	2	2				8
1986				2	1	4	4	2	2				

													15
1987				1		4		2	6				13
1988				4	1	5		3	4				17
1989				4	1	7		2	4				18
1990			3	4		10	4	4	3				28
1991				4	2	4		1	7				18
1992			3	3	2	7			4		4		23
1993					2	8	12						22
1994			2	4		1	5		4				16 (1)
1995				2		1							3 (1)
TOTAL	48	23	21	84	20	115	150	43	72	3	10	10	599

EB = Electric Boat Division of General Dynamics
SAPS = Shippingport Atomic Power Station
KSO = Kenneth A. Kesselring Site Operations
MINS = Mare Island Naval Shipyard
PHNS = Pearl Harbor Naval Shipyard
PSNS = Puget Sound Naval Shipyard
NNS = Newport News Shipbuilding
PNS = Portsmouth Naval Shipyard
CNS = Charleston Naval Shipyard
WSO = Windsor Site Operations
NOR = Norfolk Naval Shipyard
INGL = Ingalls Shipbuilding

(1) Shipments in these years cover those authorized by the court injunction.

plants are tested and qualified to characterize their performance for the lifetime of the plant. Part of this qualification program is to perform various irradiation tests of the materials for lifetime effects prior to certification. Along with those tests are pre- and post-examinations that provide the necessary data for subsequent analysis of the material in question. This work is considered a fundamental requirement for the design and safe operation of naval reactor plants. Therefore, the transfers of test specimen assemblies to the examination facility and shipments of the test specimens to the test facilities are included in the transportation evaluation. The test specimens have been assembled into test specimen assemblies and irradiated at the Test Reactor Area (TRA) on the INEL. The irradiated test specimen assemblies are returned to ECF for disassembly and examination.

Since 1956, approximately 3600 transfers of naval test specimen assemblies have been made between ECF and TRA in shipping casks transported by exclusive-use truck. For alternatives involving future transfers of this type, the transfers would be made in the NR-1, ATR-2, NR-3, NR-4, and Test Train casks. A detailed description of the shipping casks used to transfer irradiated test specimen assemblies is provided in Section A.4.3.

A.2.4 Shipments of Naval Irradiated Test Specimens to Examination

and Testing Facilities

Following disassembly and examination of the test specimen assemblies at ECF, some specimens are shipped to off-site facilities for further testing or examination. These tests and examinations are generally very specialized and ECF does not have the capability to perform them or cannot perform them in a timely manner due to other examination priorities. Specimens are also shipped back to ECF for examination or further irradiation at TRA.

Test specimen shipments have been shipped to or from several laboratories and test facilities. They are the Bettis Atomic Power Laboratory (Bettis), located in West Mifflin, Pennsylvania; the

Knolls Atomic Power Laboratory (KAPL), located in Niskayuna, New York; the Oak Ridge National Laboratory (ORNL), located in Oak Ridge, Tennessee; the Argonne National Laboratory (ANL)-East, located in Argonne, Illinois; the Battelle Memorial Institute, located in Columbus, Ohio; the Chalk River Nuclear Laboratories, located in Chalk River, Ontario, Canada (1 shipment only); the Hanford Site, located in Richland, Washington; and the ANL-West, Central Facilities Area (CFA), TRA, and ICPP facilities, all located on the INEL. Based on current schedules, Bettis and KAPL will be the only origins for future shipments. Figure A-2 provides a map of the United States showing the transportation origins and destinations for the test specimen shipments.

Since 1956, approximately 850 shipments of naval test specimens have been made between ECF and on- and off-site testing and examination facilities, in shipping containers transported by exclusive-use truck. The shipments have been made in NRBK-41, -42, -43, and -44 shipping containers and the WAPD-39 and -40 shipping containers. For alternatives involving future shipments of this type, the shipments would be made in the NRBK-41 and WAPD-40 shipping containers. A detailed description of the shipping containers used to ship irradiated test specimens between off-site facilities and the examination facility is provided in Section A.4.4.

A.3 ALTERNATIVES TO BE EVALUATED

A detailed description of the alternatives is provided in Section 3. The specific impacts on each of the four types of naval shipments (described in Section A.2) are described below for each alternative.

A.3.1 Alternative 1 - No Action

Under this alternative, after implementation, there would be no further shipments of naval spent nuclear fuel from the shipyards and prototypes. The Expended Core Facility would be shut down. Naval spent nuclear fuel would be stored at a facility at the site where it was removed during reactor servicing, with the exception of naval spent nuclear fuel removed at Newport News Shipbuilding, a commercial shipyard, which would be transported to Norfolk Naval Shipyard for storage. All naval spent nuclear fuel currently at ECF would be transferred to ICPP prior to the start of the 40-year period with the exception of the fuel saved for future examinations, referred to as reference specimens. The reference specimens and the naval spent nuclear fuel which originated at the prototype sites at NRF would be shipped from ECF to ICPP sometime during the 40-year period. The TRA facility would perform any work associated with the assembly, disassembly, and routine examination of the test train assemblies; therefore, no transfers would be required. Specimens shipped off-site would remain at the destination following examination. Table A-2 summarizes the shipments for the No Action alternative.

Figure A-2. Transportation origins and destinations for test specimen shipments.

Table A-2. Summary of shipments for the No Action alternative.

Type of Shipment	
Shipments of Naval Spent Nuclear Fuel from Shipyards and Prototypes	
- Shipyards and Prototypes to ECF	None
- Newport News to Norfolk	Yes
Transfers of Naval Spent Nuclear Fuel from ECF to ICPP	Reference Specimens and Prototype Only
Transfers of Naval Test Specimen Assemblies Between ECF and TRA	None
Shipments of Irradiated Test Specimens Between Off-Site Facilities and ECF	
- Shipments from ECF	Yes
- Shipments back to ECF	None

A.3.2 Alternative 2 - Decentralization

As described in Section 3.4, this alternative also involves storage of the naval spent nuclear fuel near the point of origin. An evaluation of each of the three subalternatives defined in Section 3 was performed. The impact of the transportation related to each subalternative is briefly described below.

A.3.2.1 Alternative 2a - Store Naval Spent Nuclear Fuel at or Close to Locations Where Removed Without

Examination. From the standpoint of transportation, this subalternative is equivalent to the No Action alternative.

A.3.2.2 Alternative 2b - Examine a Limited Amount of Naval Fuel in the Puget Sound Naval Shipyard Water

Pit Facility and Store All Naval Fuel at Navy Facilities. For this alternative, the Expended Core Facility at NRF would be shut down and only high priority spent nuclear fuel would be transported to the Puget Sound Naval Shipyard for examination. For the naval spent nuclear fuel, approximately 10 percent of the total spent nuclear fuel for the 40-year period would be shipped. Following examination, the fuel would remain at Puget Sound Naval Shipyard. As in the No Action alternative, only the reference specimens would remain at ECF after June 1995. Ten percent of the reference specimens would be transferred from ECF to Puget Sound Naval Shipyard. The remainder of the reference specimens and the naval spent nuclear fuel which originated at the prototype sites at NRF would be transferred to ICPP. The TRA facility would perform any work associated with the assembly, disassembly, and routine examination of the test specimen assemblies; therefore, no transfers would be required. Shipments of test specimens to off-site facilities for specialized examinations would continue. Test specimens shipped off-site would remain at the destination following examination. Table A-3 summarizes the shipments.

Table A-3. Summary of shipments for the Decentralization - Limited Inspection alternative.

Type of Shipment	
Shipments of Naval Spent Nuclear Fuel from Shipyards and Prototypes	
- Shipyards and Prototypes to Puget Sound	Approximately 10% of spent fuel
- Newport News to Norfolk	Yes
Transfers of Naval Spent Nuclear Fuel from ECF to ICPP	Reference Specimens and Prototype Only
Transfers of Naval Test Specimen Assemblies Between Puget Sound and TRA	None
Shipments of Irradiated Test Specimens to Off-Site Facilities	
- Shipments from TRA	Yes
- Shipments back to TRA	None

A.3.2.3 Alternative 2c - Examine All Naval Spent Nuclear Fuel at the INEL and Return to Navy Facilities

for Storage. For this alternative, all naval spent nuclear fuel would be shipped to ECF and examined as it has been in the past. Only non-destructive examinations would be performed. The spent nuclear fuel would be returned in the same condition as originally shipped. Following examination, the fuel would be returned to the originating shipyard or prototype site for storage in the same type of container with the exception that naval spent nuclear fuel which originated at Newport News Shipbuilding would be shipped to Norfolk Naval Shipyard for storage. New equipment would have to be designed and procured to handle the spent nuclear fuel which returns to the shipyard. As in the No Action alternative, only reference specimens would remain at ECF after June 1995. The naval spent nuclear fuel which originated in the prototype sites at NRF (A1W and S5G) would be transferred to ICPP. Transfers of the irradiated test specimen assemblies would continue, along with the shipments of test specimens from ECF to off-site testing or examination facilities. Specimens shipped off-site would remain at the destination following examination. Table A-4 summarizes the planned shipments for this alternative.

Table A-4. Summary of shipments for the Decentralization - Full Examination alternative.

Type of Shipment	
Shipments of Naval Spent Nuclear Fuel from Shipyards and Prototypes	
- Shipyards and Prototypes to ECF	Yes
- Newport News to Norfolk	To Norfolk from ECF
Transfers of Naval Spent Nuclear Fuel from ECF to ICPP	NRF Prototypes
Transfers of Naval Test Specimen Assemblies Between ECF and TRA	Yes
Shipments of Irradiated Test Specimens to Off-Site Facilities	
- Shipments from ECF	Yes
- Shipments back to ECF	None

A.3.3 Alternative 3 - 1992/1993 Planning Basis

This alternative plans on making the same types of shipments described in Section A.2 of this attachment. The only difference is that some of the historical origins of naval spent nuclear fuel and some destinations for the test specimen shipments will not be used. Table A-5 summarizes the planned shipments for this alternative.

Table A-5. Summary of shipments for the 1992/1993 Planning Basis alternative.

Type of Shipment	
Shipments of Naval Spent Nuclear Fuel from Shipyards and Prototypes	
- Shipyards and Prototypes to ECF	Yes
- Newport News to Norfolk	No
Transfers of Naval Spent Nuclear Fuel from ECF to ICPP	Yes
Transfers of Naval Test Specimen Assemblies Between ECF and ATR	Yes
Shipments of Irradiated Test Specimens to Off-Site Facilities	
- Shipments from ECF	Yes
- Shipments back to ECF	Yes

A.3.4 Alternative 4 - Regionalization

As described in Section 3.4, this alternative would distribute existing and new spent nuclear fuel between various sites either on the basis of the fuel type or on the basis of dividing storage between the eastern and western parts of the United States. An evaluation of each of the options for this alternative described in Section 3.4 was performed. The impact of the transportation related to each option under this alternative is briefly described below.

A.3.4.1 Alternative 4a - Regionalization Using Storage at Three Sites.

From the standpoint of transportation of naval spent nuclear fuel and test specimens, this alternative is equivalent to the 1992/1993 Planning Basis alternative.

A.3.4.2 Alternative 4b - Regionalization Using Storage at Two Sites.

This alternative would utilize an existing DOE site in the eastern part of the United States and another existing DOE site in the western part of the country for storage of spent nuclear fuel. From the standpoint of transportation of naval spent nuclear fuel and test specimens, this alternative is equivalent to the Centralization alternative at each of the DOE sites because the Navy would operate a facility for examining naval spent nuclear fuel at only one of the DOE sites and the naval spent nuclear fuel would be stored at the same site where it was examined.

A.3.5 Alternative 5 - Centralization

This alternative considers consolidating all naval spent nuclear fuel and test specimens at the INEL, Hanford Site, Savannah River Site, Oak Ridge Reservation, or Nevada Test Site. Centralization at INEL is identical to the 1992/1993 Planning Basis alternative. For the other centralization sites, the type and number of shipments would be identical to the 1992/1993 Planning Basis alternative with the only difference being the destination. The naval spent nuclear fuel will be shipped to the centralization site for examination and subsequently transferred to a storage facility at the centralization site which would be equivalent to ICPP. Naval spent nuclear fuel shipments from Newport News Shipbuilding to Norfolk Naval Shipyard would not be necessary. As in the No Action alternative, only reference specimens would remain at ECF after June 1995. All reference specimens would be shipped to the centralization site. The naval spent nuclear fuel which originated in the prototype sites at NRF would also be transferred to the centralization site. The test specimen assembly shipments would be shipped between TRA and the alternate site. The test specimen shipments would originate at the centralization site and all specimens would ultimately return to that site for storage.

A.4 GENERAL DESCRIPTIONS

The following general information is common to all of the alternatives evaluated.

A.4.1 Spent Nuclear Fuel Shipping Containers

For naval spent nuclear fuel, the M-130, M-140, and M-160 shipping containers would be used for all alternatives. The shipping containers are primarily transported by railcars used only for this purpose as part of general-use freight trains. Section A.2.1 describes the special circumstances where the shipping containers are transported by ship or heavy-lift transporter. A brief description of each shipping container follows.

A.4.1.1 M-130 Shipping Container. The M-130 shipping container is a large, lead-lined, steel-shelled

shipping container that is transported in the vertical position on a depressed center railcar (Figure A-3). The major components of the M-130 shipping container include the shielded container, closure head, and dust cover. Module holders are installed inside the container to hold the irradiated fuel modules in place and can be modified to accept different sized fuel modules. The container is shipped dry with the exception of a small amount of residual water. Cooling fins on the outside of the container are designed to dissipate the heat generated by the spent nuclear fuel.

Figure A-3. M-130 shipping container mounted on railcar.

The M-130 shipping container weighs approximately 214,500 pounds in the standard loaded configuration. The container is approximately 13 feet tall and 7 feet in diameter. The container is a closed bottom cylindrical lead shell that is covered both on the inside and the outside with a 1-inch thick layer of steel. The lead on the cylindrical sides is about 10 inches thick and is a minimum of 9.5 inches thick on the bottom. In the standard configuration, the closure head at the top of the container is primarily constructed of 5.25 inches of lead and 7 inches of steel.

A.4.1.2 M-140 Shipping Container. The M-140 shipping container is a large, stainless steel shipping

container that is transported in the vertical position on a specially designed well-type railcar (Figure A-4). The major components of the M-140 shipping container include the shielded container, closure head, and protective dome. Module holders are installed inside the container to hold the irradiated fuel modules in place and can be modified to accept different sized fuel modules. The container is shipped dry with the exception of a small amount of residual water. Cooling fins on the outside of the container are designed to dissipate the heat generated by the fuel.

The M-140 shipping container weighs approximately 375,000 pounds in the loaded condition. The container is approximately 16 feet tall with a maximum diameter of 10.5 feet. The container body is made from stainless steel forgings with 14-inch thick walls and a 12-inch thick bottom. The closure head and protective dome have a total thickness of 17.5 inches of stainless steel.

A.4.1.3 M-160 Shipping Container. The M-160 shipping container is a large, lead-lined, steel-shelled

shipping container that is transported in a horizontal position on a support structure mounted on a modified flat bed railcar (Figure A-5). The major components of the M-160 shipping container include the shielded container, closure head, and dust cover. Module holders are installed inside the container to hold the irradiated fuel modules in place. The container is shipped dry with the exception of a small amount of residual water. Cooling fins on the outside of the container are designed to dissipate the heat generated by the fuel.

Figure A-4. M-140 shipping container mounted on railcar. Figure A-5. M-160 shipping container mounted on railcar.

The M-160 shipping container weighs approximately 235,500 pounds in the loaded condition. The container is approximately 16.5 feet long and 6.5 feet in diameter. The container consists of two concentric bottom closed steel cylinders with a 9.4-inch annulus between the cylinders that is filled with lead. The outer shell is made from 1.5-inch thick steel, and the inner shell is made from 1-inch thick steel. The bottom plate is approximately 7 inches thick, and the closure head is approximately 15 inches thick.

A.4.1.4 Government Escorts for Spent Nuclear Fuel. Commercial railroads, exclusive-use heavy-lift

transporters, or exclusive-use ships are used to transport the naval spent nuclear fuel from the prototypes and shipyards. The specific routes used to transport the spent nuclear fuel are selected by the rail or shipping companies. All naval spent nuclear fuel shipments are accompanied by government escorts. The escorts perform the duties necessary to ensure the safe, expeditious transportation of the naval spent nuclear fuel.

The government escorts receive specialized training in shipment safety procedures, radiological controls, security, and emergency response. Routine shipment escort procedures involve processing of authorization and shipping documentation, pre-shipment inspections, tracking shipment progress and schedules, enroute inspections, shipment observation and surveillance, and periodic communication checks. The government escorts have been trained to use and are equipped with the necessary radiological monitoring equipment to verify the shipping container integrity.

A large amount of the government escorts' training involves emergency response. This training involves emergency procedures for notification of technical and safeguards support personnel. The government escorts are equipped to immediately notify emergency assistance personnel, immediately assess the containment status of the shipping container, and communicate this information to emergency support personnel. Depending on the situation, the technical and support personnel may activate various emergency control centers that are prepared to provide the government escorts with the necessary support to quickly and safely bring an emergency situation under control. All railroads, which handle escorted shipments, also have specific emergency response procedures to safely expedite recovery for shipments that are involved in a rail line accident. Continually manned railroad operation centers maintain the capability to contact personnel from a combination of resources which provide appropriate equipment and manpower at the accident scene.

A.4.2 Spent Nuclear Fuel Shipping Casks for Transfers to Storage Following Examination

For naval spent nuclear fuel being transferred from the examination facility to storage (e.g., ECF to ICPP), the Nuclear Fuel Services Model 100 cask (NFS-100), Peach Bottom cask, and the Large Cell cask will be used for all alternatives. These shipping containers are transported by exclusive-use truck. A brief description of each cask follows.

A.4.2.1 NFS-100 Cask. The NFS-100 cask is a large, lead-lined, steel-shelled shipping cask that is transported in the horizontal position on a skid assembly attached to a tandem axle trailer (Figure A-6). The major components of the NFS-100 cask include the shielded cask and closure head. A fuel holding insert is installed inside the cask to hold the irradiated fuel modules in place. The container is shipped dry with the exception of a small amount of residual water. The cask is enclosed on the truck by a metal cover during shipment.

The NFS-100 cask weighs approximately 110,000 pounds in the loaded configuration. The cask is approximately 10.5 feet tall and 7 feet in diameter. The cask is a closed bottom cylinder of lead with a 0.375-inch thick steel inner shell and a 2-inch thick outer shell. The lead on the cylindrical sides is about 8.75 inches thick and the lead on the bottom is 8.8 inches thick. The closure head at the top of the cask is constructed of 9.75 inches of lead and 2 inches of steel.

A.4.2.2 Peach Bottom Cask. The Peach Bottom cask is a large, lead-lined, steel-shelled shipping cask that is transported in the horizontal position on a skid assembly attached to a tandem axle trailer (Figure A-7). The major components of the Peach Bottom cask include the shielded cask and closure heads. A fuel holding insert is installed inside the cask to hold the irradiated fuel modules in place. The cask is shipped dry with the exception of a small amount of residual water. The cask is enclosed on the truck by a metal cover during shipment.

Figure A-6. NFS-100 cask mounted on truck. Figure A-7. Peach Bottom cask mounted on truck.

The Peach Bottom cask weighs approximately 68,400 pounds in the loaded configuration. The cask is approximately 16 feet tall and 3.5 feet in diameter. The cask is a stepped cylinder of lead with a 0.25-inch thick steel inner shell and a 1.75-inch thick steel outer shell. The lead on the cylindrical sides ranges from 5.25 to 6.25 inches thick. The closure heads on each end of the cask are essentially identical and are constructed of 8.5 inches of steel.

A.4.2.3 Large Cell Cask. The Large Cell cask, currently being designed for larger fuel types, will be a

large, stainless steel shipping cask that is transported in the vertical position on a low-boy tractor trailer (Figure A-8). The major components of the Large Cell cask will include a shielded cask, closure head, shipping cask, and external impact limiters. Fuel-holding inserts will be installed inside the cask to hold the irradiated fuel modules in place. The cask will be shipped dry with the exception of a small amount of residual water. Cooling fins on the outside of the shipping cask are designed to dissipate the heat generated by the fuel.

The Large Cell cask will weigh approximately 220,000 pounds in the loaded condition. The shielded cask will be approximately 14 feet tall and 7 feet in diameter. The shielded cask body will be a closed bottom cylinder made from stainless steel forgings with 13.5-inch thick walls and a 13-inch thick bottom. The closure head will be a 14-inch thick stainless steel forging. The shielded cask will be assembled to the shipping cask during transport. The shipping cask will be a 2-inch thick aluminum closed bottom cylinder with fins extending to a total diameter of 93.6 inches. The external impact limiter assemblies, located on both ends of the cask, will be constructed of encased bi-directional aluminum honeycomb and are approximately 10 feet in diameter. The total Large Cell cask height will be approximately 17 feet.

A.4.2.4 Shipment Controls. All spent nuclear fuel transfers to a storage facility at the same site as the

examination facility will be accompanied by escorts. The escorts are personnel who are specially trained to perform the duties necessary to ensure the safe transportation of the spent nuclear fuel. The escorts are in vehicles located in front of and behind the truck carrying the shipping cask.

The escorts receive specialized training in shipment safety procedures, radiological controls, security, and emergency response. The escort vehicles are equipped with distinctive warning flashers, and the escorts are capable of radio contact with each other, the driver of the transport vehicle, and on-site emergency coordinating personnel.

Figure A-8. Large Cell cask.

A large amount of the escorts' training involves emergency response. This training involves emergency procedures for notification of site technical and safeguards support personnel. The escorts are equipped to immediately notify emergency assistance personnel, immediately assess the containment status of the shipping cask, and communicate this information to emergency support personnel. Depending on the situation, the technical and support personnel may activate various emergency control centers that are equipped with the equipment and manpower to provide the escorts with the necessary support to quickly and safely bring an emergency situation under control.

Additional administrative controls are imposed on the transfers to further minimize risks. For example, the transfers are not allowed to travel during heavy traffic periods such as shift changes, and the convoy travels at reduced speeds. The route itself also enhances safety, since the route is essentially flat and the highest possible drop distance in the event of an accident is approximately 5 meters (16.5 feet) at the location where the highway crosses a river bed.

A.4.3 Naval Test Specimen Assembly Casks for Transfers Between

TRA and the Examination Facility

For naval test specimen assemblies being transferred on-site between TRA and the examination facility, the NR-1, ATR-2, NR-3, NR-4, and Test Train casks will be used. These casks are transported by exclusive-use truck. For off-site shipments to the examination facility at the centralization sites, only the Test Train cask will be used. A brief description of each cask follows.

A.4.3.1 NR and ATR Casks. The NR and ATR casks are large, lead-lined, steel-shelled casks that are transported approximately 10y off horizontal in a cradle assembly attached to a tandem trailer (see Figure A-9). The major components of the casks include the shielded body, mast, and bottom closure/shield.

The shielded bodies of the casks are all approximately 32 inches in diameter. The outer steel shell thickness ranges from 0.5 inch to 1.0 inch. The thickness of the inner steel shell is approximately 0.4 inch for each cask. The lead ranges from approximately 10 inches to 11 inches for the various casks. The height of the shielded body ranges from approximately 6 feet to 12 feet. The mast is a tower section formed of reinforced aluminum and serves to support the structural end of the specimen assemblies which require very little shielding. A winch and platform are also attached to each cask. The bottom closure/shield is constructed of 1.0 to 1.75 inches of steel and 7.0 to 8.75 inches of lead.

Figure A-9. NR/ATR cask mounted on truck.

The NR and ATR casks range in weight from approximately 19,000 to 48,000 pounds. The overall cask height ranges from approximately 20 to 30 feet.

A.4.3.2 Test Train Casks. A new test specimen container would be required to transport irradiated test specimen assemblies between TRA and the examination facility located at the sites other than INEL for the Centralization alternative. A new cask is currently being designed to replace the current casks used to transport the test specimen assemblies between ECF and TRA, which are approaching the end of their design lifetime. The basic concept for this new cask is a thick-walled, stainless steel body with stainless steel closures on each end. Energy absorbers will be attached to the cask to prevent damage to the test specimens. The current estimated size of this cask is 34 feet long by 5 feet in diameter, weighing approximately 40 tons. This cask would be shipped by exclusive-use truck.

A.4.3.3 Shipment Controls. All spent nuclear fuel transfers to an examination facility at the same site as the irradiation facility will be accompanied by two escorts. The escorts are personnel who are specially trained to perform the duties necessary to ensure the safe transportation of the spent nuclear fuel. The escorts are in vehicles located in front of and behind the truck carrying the shipping cask.

The escorts receive specialized training in shipment safety procedures, radiological controls, security, and emergency response. A large amount of the escorts' training involves emergency response. This training involves emergency procedures for notification of site technical and safeguards support personnel. The escorts are equipped to immediately notify emergency assistance personnel, immediately assess the containment status of the shipping cask, and communicate this information to emergency support personnel. Depending on the situation, the technical and support personnel may activate various emergency control centers that are equipped with the equipment and manpower to provide the escorts with the necessary support to quickly and safely bring an emergency situation under control. The escort vehicles are equipped with distinctive warning flashers, and the escorts are capable of radio contact with each other, the driver of the transport vehicle, and emergency coordinating personnel.

Additional administrative controls are imposed on the shipments to further minimize risk. For example, the transfers are not allowed to travel during heavy traffic periods such as shift changes, and the convoy travels at reduced speeds. The route itself also enhances safety, since the route is essentially flat and the maximum possible drop in the event of an accident is from the bed of the truck to the road bed.

For the Centralization alternative, the casks would be shipped off-site. In this instance, only casks certified for over-the-road transportation in accordance with the Nuclear Regulatory Commission regulations would be used for shipments of the test trains. No escorts or additional administrative controls would be used.

A.4.4 Test Specimen Shipping Containers

For test specimens, the WAPD-40 and NRBK-41 shipping containers would be used to transport the specimens between ECF and the off-site laboratories and test facilities for all alternatives. These shipping containers are transported by an enclosed truck using a commercial carrier. A brief description of each container follows.

A.4.4.1 WAPD-40 Shipping Container. The WAPD-40 shipping container (Figure A-10) is a cylindrical,

lead-shielded, steel-clad container that is shipped in a horizontal position. The inner steel shell is 0.25-inch thick, and the outer steel shell is 0.5-inch thick with 9.875 inches of lead shielding in between. The container is approximately 13 feet long and 2 feet in diameter. Steel clad, lead-shielded end plugs bolt onto each end, and 0.5-inch thick plates are bolted over the end plugs. The specimens are placed into special sealed inner containers prior to placement into the WAPD-40 shipping container. The weight of the container and skid assembly is approximately 28,000 pounds. The container and skid assembly are mounted into a special holddown cradle on the truck. This holddown cradle weighs approximately 5,000 pounds.

A.4.4.2 NRBK-41 Shipping Container. The NRBK-41 shipping container (Figure A-11) is a cylindrical,

lead-shielded, steel-clad container that is shipped in the vertical position. The inner steel shell is 0.25-inch thick, and the outer steel shell is 0.5-inch thick with 10 inches of lead shielding in between. The container has a 1-inch thick steel plate welded to the bottom with a second 1-inch thick steel plate welded to the first plate with a 0.125-inch deep recess to provide a thermal break for the bottom of the container. The container also has a 0.25-inch thick steel outer thermal shield attached that provides a 0.125-inch air gap between the outer shell and the thermal shield. The container is approximately 4 feet tall and 2.25 feet in diameter. The container is bolted to a welded 48-inch square I-beam skid that is used to distribute the container load. The specimens are placed into a special sealed inner container prior to placement into the NRBK-41 shipping container. The weight of the loaded container is approximately 9,000 pounds.

Figure A-10. WAPD-40 shipping container. Figure A-11. NRBK-41 shipping container.

A.4.5 Shipping Container Design Requirements

The M-130, M-140, M-160, NRBK-41, and WAPD-40 shipping containers have been designed and built to meet the regulations specified in Title 49, Code of Federal Regulations, Part 173 (49CFR173), entitled " Shippers - General Requirements for Shipments and Packagings" (CFR 1991). Shipments of naval spent nuclear fuel and test specimens are further regulated by Title 10, Code of Federal Regulations, Part 71 (10CFR71), entitled "Packaging of Radioactive Material for Transportation and Transportation of

Radioactive Material Under Certain Conditions" (CFR 1993). These regulations require the shipping container to meet specific criteria under normal transport and accident conditions. The shipping container must be evaluated under free drop, puncture, heat, cold, pressure, water spray, and vibration for normal conditions and a series of severe hypothetical accident conditions with the results compared against the criteria provided in 10CFR71.

The M-130, M-140, M-160, WAPD-40, and NRBK-41 shipping containers have undergone rigorous engineering evaluations to assure compliance with 49CFR173 and 10CFR71 requirements. In addition, actual scale model or mock-up tests have been performed to verify selected engineering evaluations. This compliance has been certified by the U. S. Department of Energy and the Nuclear Regulatory Commission. The new Test Train and Large Cell casks will also be designed in accordance with the requirements of 49CFR173 and 10CFR71 and will undergo the same rigorous engineering evaluations and testing.

The safety analyses for the NFS-100, Peach Bottom, NR, and ATR casks demonstrate compliance with the requirements specified by the Department of Energy (DOE) in DOE Order 5480.3, entitled "Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes" (DOE 1985) and supplemented by DOE Idaho Operations Office Order ID 5480.3, entitled "Hazardous Materials Packaging and Transportation Safety Requirements" (DOE 1991). These requirements are similar to the requirements of 10CFR71 with the major difference being that a worst credible accident can be defined based on site-specific information.

The NFS-100, Peach Bottom, NR, and ATR casks have undergone rigorous engineering evaluations to assure compliance with the DOE requirements. In addition, actual scale model or mock-up tests have been performed to verify selected engineering evaluations. The shipping casks comply with the requirements of DOE 5480.3 and DOE ID 5480.3 and this compliance is demonstrated by approval from the Idaho Operations Office of the Department of Energy.

A.5 TECHNICAL APPROACH - GENERAL

Several computer codes were used to assess the radiological risks associated with the transportation of naval spent nuclear fuel and test specimens. Specifically, the RADTRAN 4 risk analysis model, developed by Sandia National Laboratories (Neuhauser and Kanipe 1992), was used to calculate the general population and transportation crew (occupational) radiological risks associated with the transportation of radioactive materials. This computer code was used extensively in the incident-free and accident risk assessments. In some cases, other methods were more appropriate than the RADTRAN 4 computer code for naval spent nuclear fuel. In these cases, other calculational models were used and are specifically identified.

The RISKIND computer code, developed by Argonne National Laboratory (Yuan et al. 1993), also specifically analyzes radiological consequences and health risks to individuals from exposure associated with transportation. For incident-free evaluations, RISKIND uses a generic truck cask and does not allow adjustments for different sized casks which is not appropriate for naval spent nuclear fuel and test specimen casks; therefore, this code was not used. RISKIND (a version which accepts fuel-specific isotopes) was found to be the best code for calculation of the maximum individual and general population consequences for the accident scenario and was used for that purpose.

Several other computer codes were used to provide input for the RADTRAN 4 and RISKIND computer codes. The codes include INTERLINE, HIGHWAY, SPAN4, and ORIGEN2. A description of each computer code and how the code was used is provided below.

The INTERLINE computer code, developed by Oak Ridge National Laboratory (Johnson et al. 1993a), was used to evaluate the rail routes used for the spent nuclear fuel shipments.

The HIGHWAY computer code, also developed by Oak Ridge National Laboratory (Johnson et al. 1993b), was used to evaluate the truck routes used for the test specimen shipments.

The SPAN4 computer code (Wallace 1972) was used to perform gamma exposure rate calculations for the various shipping containers to assess the effect of increased distance from the source on exposure. SPAN4 is a point kernel code where appropriate exponential kernels are integrated over a source distribution. SPAN4 was developed by the Bettis Atomic Power Laboratory specifically for naval spent nuclear fuel.

The ORIGEN2 is a computer code, developed by Oak Ridge National Laboratory (Croff 1980), that is used to simulate radiation and decay of materials that are irradiated in a nuclear reactor. The ORIGEN2 computer code is widely accepted in the public domain and was used to independently confirm the fission product inventory for naval fuel developed using the standard Bettis Atomic Power Laboratory method. In addition, the standard Bettis Atomic Power Laboratory method has been used in Safety Analysis Reports for Packaging, reviewed and accepted by the Nuclear Regulatory Commission.

The radiological risks associated with the transportation of spent nuclear fuel and irradiated test specimens have been assessed for the general population, transportation workers (occupational), and hypothetical maximum exposed individuals under incident-free and accident conditions for the alternatives presented in Section A.3. The maximum consequences for an accident are also provided for each alternative. The radiation exposure to the government escorts for shipments was considered occupational in nature and was included with the transportation worker results.

The radiological impacts are first expressed as the calculated total exposure for the exposed population, occupational workers, and the maximum exposed individuals. The calculated total exposures are then used to estimate the hypothetical health effects, expressed in terms of estimated cancer fatalities. The health risk conversion factors used in this evaluation are taken from the International Commission on Radiological Protection (ICRP Publication 60) which specifies 0.0005 fatal cancer cases per person-rem for members of the public, 0.0004 fatal cancer cases per person-rem for workers (ICRP 1991). To calculate the estimated health detriment, the calculated exposure would be multiplied by the conversion factors of 0.00073 health detriments per person-rem for members of the public, and 0.00056 health detriments per person-rem for workers (ICRP 1991).

The numerical estimates of cancer deaths and other health detriments presented were obtained by the practice of linear extrapolation from the nominal risk estimate for lifetime total cancer mortality at 10 rad. Other methods of extrapolation to the low-dose region could yield higher or lower numerical estimates of cancer deaths. Studies of human populations exposed at low doses are inadequate to demonstrate the actual level of risk. There is scientific uncertainty about cancer risk in the low-dose region below the range of epidemiologic observation, and the possibility of no risk cannot be excluded (CIRRPC 1992). In this appendix, the doses have been provided in all cases to allow independent evaluation using any relation between exposure and health effects.

Non-radiological risks related to the transportation of naval spent nuclear fuel are also estimated. The non-radiological risks are associated with vehicle exhaust emission for incident-free transportation and fatalities resulting from transportation accidents. The non-radiological risks associated with shipments that return empty containers to the origin are also included. Risk factors for vehicle exhaust emissions and state-level accident fatality rates were obtained from "Non-Radiological Impacts of Transporting Radioactive Material" (Rao et al. 1982), "Transportation Impacts of the Commercial Radioactive Waste Management Program" (Cashwell et al. 1986), and "Longitudinal Review of State-Level Accident Statistics for Carriers of Interstate Freight" (Saricks and Kvitek 1994), respectively.

The shipments of radioactive waste at shipyards are not addressed. The exposure related to incident-free transportation would be small and would be the same for all alternatives which would not affect the decision-making process. The consequences of an accident would also be insignificant compared to the accidents analyzed for spent nuclear fuel.

For the ocean-going portion of the shipments of naval spent nuclear fuel from shipyards and prototypes, there would be no exposure to the general population. The basis for this conclusion is that the ship's hull provides a considerable amount of additional shielding and that there would be no members of the general population close enough to the ship to receive appreciable exposure during these shipments. The consequences of an accident during the ocean-going portion have also not been evaluated because the forces on the container during an accident aboard the ship would not be large enough to cause damage to the container or fuel inside it since the ship itself would sustain the direct impact. This is substantiated by the fact that the impact forces to the container would be less than the regulatory criteria. Therefore, no release would occur.

A.5.1 Technical Approach for the Assessment of

Incident-free Transportation

For incident-free transportation of naval spent nuclear fuel, the RADTRAN 4 computer code was used to calculate the radiological exposure for the general population and a portion of the occupational exposure.

Included in the RADTRAN 4 computer code incident-free risk calculations for transport are models describing (1) exposures to persons (e.g., residents) adjacent to the transport route (off-link exposures), (2) exposures to persons (e.g., passengers on passing trains or vehicles) sharing the transport route (on-link doses), (3) exposures to persons at stops (e.g., residents or rail and truck crew not directly involved with the shipment), and (4) exposures to transportation crew members (occupational). The exposures calculated for the first three groups were added together to estimate the general population exposure estimates for rail and truck transport; the exposure calculated for the fourth group represents occupational exposure to the rail crew exposures during inspections and truck crew during transit and inspections. Table A-6 summarizes the calculational methods used for each group for the shipment of naval spent nuclear fuel and test specimens.

As shown in Table A-6, simple calculations were performed to account for situations where the RADTRAN 4 computer code was not the best calculational model with respect to the transportation of naval spent nuclear fuel. The information used in the simple calculations was based on historical information. The results obtained using these simple calculations are expected to be equal to or greater than any exposures which might actually occur.

The maximum possible radiological exposure to an individual for the routine transport of naval spent nuclear fuel and test specimens off-site was estimated for transportation workers, as well as members of the general population. For rail shipments, the three general population scenarios were: (1) a railyard worker who might be working at a distance of 10 meters (32.8 feet) from the shipping container for 2 hours, (2) a resident who might live 30 meters (98.4 feet) from the rail line

Table A-6. Calculational methods used to obtain exposures for population groups of interest.

Shipment Type	Origin	Destination(a) a)	Mode	General Population			Occupational	
				Off-Link and On-Link	Stops	Maximum Individuals	Workers	Escorts
Spent Nuclear Fuel to ECF or Equivalent	Kesselring Site	Ballston Spa	Truck	(1)	(3)	(6)	(3)	(3)
	Shipyard/Rail Siding	Various	Rail	(1)	(1)	(6)	(2)	(5)
	Windsor Site	Griffen Siding	Truck	(1)	(3)	(6)	(3)	(3)
	Pearl Harbor	Puget Sound	Ship	N/A	N/A	N/A	(4)	(4)
Spent Nuclear Fuel to Storage	ECF or Equivalent	Various	Truck	(1)	(1)	(6)	(1)	(1)

Test Specimen Assemblies	TRA	Various	Truck	(1)	(1)	(6)	(1)	(1)
Test Specimens	ECF or Equivalent	Bettis/ KAPL, etc.	Truck	(1)	(1)	(6)	(1)	N/A

Calculational Methods:
(1) RADTRAN 4 calculations.
(2) RADTRAN 4 rail calculations for inspection exposure and simple calculations based on rail transportation data supplied by the government escorts for rail transit exposure.
(3) Simple calculation model based on truck transportation data supplied by site personnel.
(4) Simple calculation model based on ship transportation data supplied by Pearl Harbor Naval Shipyard.
(5) Exposures based on historical TLD readings.
(6) Simple calculation model based on scenarios provided in RISKIND.
(a) The methods provided in this table apply to the destination for all the alternatives evaluated.

where the shipping container was being transported, and (3) a resident who could be living 200 meters (656.2 feet) from a rail stop where the shipping container was sitting for 20 hours. The government escorts and crew members from the rail, heavy-lift transporter, and ship were evaluated for the transportation workers (occupational). Based on records of past escorted rail shipments, the government escort might be the same individual for as many as two-thirds of the shipments in a 5-year period. The crew members were postulated to be the same individuals for all shipments in the 40-year period.

For off-site truck shipments, the three scenarios for the general population were: (1) a person who might be caught in traffic and located 1 meter (3 feet) away from the surface of the shipping container for one-half hour, (2) a resident who might be living 30 meters (98.4 feet) from the highway used to transport the shipping container, and (3) a service station worker who might be working at a distance of 20 meters (65.6 feet) from the shipping container for 2 hours. The hypothetical maximum exposed individual radiological exposures were accumulated over the 40-year period. However, for the situation involving an individual who might be caught in traffic next to a truck transporting spent nuclear fuel, the radiological exposures were only calculated for one event since it was considered unlikely that the same individual would be caught in traffic next to all containers for all shipments. For truck shipments, the occupational maximum exposed individual is the driver. For each of the categories of truck shipments described in Sections A.4.2 through A.4.4, the calculations used a single individual as the driver for all shipments made in the past. For shipments in the 40-year period being evaluated, a single person was also used in the calculations as the driver for all shipments of each category.

The hypothetical maximum exposed individual scenarios for the general population described above were not applicable for on-site shipments of naval spent nuclear fuel and test specimens for two reasons. The first is that there are no members of the general population in the vicinity during the on-site shipments. The second reason is that an obstruction, if encountered, would be safely avoided under the direction of the escorts. Two alternate scenarios were developed. They were: (1) a site employee in a disabled vehicle along the transport route, located 10 meters (32.8 feet) from the container and (2) a site employee trailing the slow-moving transport vehicle for the entire trip. These scenarios were considered to be single-event occurrences.

As noted in Table A-6, simple methods were also used to calculate radiological exposures. For radiological exposures to personnel at a fixed distance from the shipping container, the following equation was used.

Exposures to personnel at a fixed distance from the container:
= N x NBA x T x SF x K x TI / D2

where:
N = number of people
NBA = factor to account for exposure decrease at increased distance from the source (attenuation/buildup). (Refer to Neuhauser and Kanipe 1993.)
T = time

SF = shielding factor
K = transport index to exposure rate conversion factor
TI = transport index (see Section A.7.1.1.2)
D = distance from the centerline.

For the radiological exposures associated with the ship transport of spent nuclear fuel from the Pearl Harbor Naval Shipyard to the Puget Sound Naval Shipyard, the following general equations were used:

Exposures to personnel aboard ship during transport:

$$= N \times NBA \times T \times SF \times K \times TI \times (1/(X1 + X2)2 + 1/X22)$$

where:

X1 = distance between the centerlines of the two shipping containers
X2 = distance between centerline of the nearest shipping container and the exposed individual

Exposures to personnel aboard ship during inspections:

$$= (N \times T \times TI) + (N \times NBA \times T \times K \times SF \times TI / (X1 - R - 1)2)$$

where:

R = effective radius to account for the exposure from the second shipping container.

Table A-7 provides an estimate of the number of people included in the analyses. To determine this number, the basic equation used was:

(Distance Traveled) x (Exposure Path Width) x (Density of People).

In each alternative, there are many shipments from several different origin/destination combinations. Since the route would be the same for each shipment from the same origin/destination combination, the people along the route would also not change, therefore, the distance used was from one trip for each origin/destination combination. The exposure path width is 1.6 kilometers (1 mile), consistent with the RADTRAN 4 computer code methodology for incident-free calculations. The population density was calculated by summing the product of the fraction of travel times the density in each population area (rural, suburban, and urban). The fraction of travel and density were obtained from HIGHWAY and INTERLINE. The total number of people was then calculated by summing the results of all origin/destination combinations for each alternative.

Table A-7. Estimated number of people included in incident-free transportation analyses.

Alternative	Number of People
No Action	890,000
Decentralization - No Examination	890,000
Decentralization - Limited Examination	9,240,000
Decentralization - Full Examination	6,820,000
1992/1993 Planning Basis	7,290,000
Regionalization or Centralization at INEL	7,290,000
Regionalization or Centralization at Hanford	8,370,000
Regionalization or Centralization at Savannah River	6,950,000
Regionalization or Centralization at Oak Ridge	5,660,000
Regionalization or Centralization at Nevada Test Site	8,320,000

A.5.2 Technical Approach for Transportation Accidents

The RADTRAN 4 computer code was used to calculate the radiological risk to the general population and transportation (occupational) crew under accident conditions. The RADTRAN 4 computer code evaluates six pathways for radiation exposures resulting from an accident. The six potential pathways are:

- Direct Radiation Exposure from the Damaged Container
- Inhalation Exposure from the Plume of Radioactive Material Released from the Damaged Container
- Direct Radiation Exposure from Immersion in the Plume of Radioactive Material Released from the Damaged Container
- Direct Radiation Exposure from Ground Deposition of the Radioactive Material Released from the Damaged Container
- Inhalation Exposure from Resuspension of the Radioactive Material Deposited on the Ground
- Ingestion Exposure from Food Products Grown on the Soil Contaminated by Ground Deposition of Radioactive Material Released from the Damaged Container.

For each pathway, a specific formula is used to determine an estimate of the radiological risk, expressed in exposure, from that particular pathway with the total radiation exposure equal to the sum of the exposure for each pathway. The total accident radiation exposure accounts for the probability of an accident occurring and the probability of an accident of a particular severity. It should be noted that all consequences are included in the risk assessment, regardless of the probability. The general equation for the population exposure from all pathways is:

DR = -c,r (Nc x Lr,c x Pr x -i,j,k (Pj x RFj x Di,j,k))

where: DR = population exposure from the accident
Nc = number of naval spent nuclear fuel modules shipped of fuel type c
Lr,c = shipment distance for fuel type c shipped through state r
Pr = frequency of traffic accidents
Pj = probability of occurrence of accident severity category j
RFj = fraction of curies released from shipping container by severity category j
Di,j,k = radiation exposure resulting from accident severity category j through pathway i in population density zone k.

The accident risk evaluation was performed using neutral and stable atmospheric conditions (Pasquill Stability Classes D and F, respectively). The neutral atmospheric condition results provide a best estimate of the risk. Stable atmospheric conditions resulted in values approximately twice the neutral conditions, ignoring the lower probability of occurrence.

In addition to the estimation of the radiological risk of an accident described above, an evaluation of the consequences of an accident of the highest severity was performed. The consequences, expressed as radiological exposure, are calculated for the maximum exposed individual and the general population. Exposures to the general population were calculated for each of the three population density regions (rural, suburban, and urban). The maximum exposed individual was placed in the population area which resulted in the highest exposure.

The RISKIND computer code, modified by its authors to accept the fission product inventory unique to naval spent nuclear fuel, was used to calculate the maximum consequences. The pathways evaluated by RISKIND are identical to those used in the RADTRAN 4 computer code for the risk evaluation.

The maximum consequence evaluation presents the consequences for design basis accidents, defined as those accidents which have a probability of greater than 1 x 10y6 per year, and beyond design basis accidents, defined as those which have a probability of 1 x 10y6 to 1 x 10y7 per year. Accidents with a probability of less than 1 x 10y7 were not analyzed in the maximum consequence evaluation.

To determine the overall probabilities, the probability of an accident, the probability of the consequences, fraction of travel in each population area, and probability of the meteorological conditions had to be determined.

The probability of the accident was calculated by multiplying the accident rates for each state times the distance traveled in each state times the number of shipments. The results were summed for each combination of origin and destination for the alternative.

As described later in Section A.7, a study performed by Lawrence Livermore National Laboratory entitled "Shipping Container Response to Severe Highway and Railway Accident Conditions" (NUREG 1987) grouped accidents into categories by strain and container mid-wall temperatures and calculated the probabilities of accidents of each category. Section A.7 also describes the consequences associated with each accident category for the naval spent nuclear fuel and test specimen shipments. The probabilities were summed for the categories which have the same consequences.

The fraction of travel in each population area (rural, suburban, and urban) was obtained from INTERLINE and HIGHWAY for each origin/destination combination. Each alternative consists of many shipments from various origin/destination combinations; therefore, an overall fraction was calculated. The overall fraction, by alternative, was calculated by multiplying each origin/destination fraction (from INTERLINE and HIGHWAY) by the number of shipments from that particular origin/destination combination, summing the results and dividing by the total number of shipments.

To calculate the probability of the meteorological conditions, Pasquill Class D was considered to be equivalent to 50% meteorology; that is, 50% of the time, conditions are expected to be more severe, and 50% of the time, conditions are expected to be less severe. Pasquill Class F was considered to be equivalent to 95% meteorology; that is, 5% of the time, it is more severe, and 95% of the time, it is less severe. Since the difference in 50% (1 chance in 2) and 95% (1 chance in 20) is a factor of 10, the probability of encountering Pasquill Class F was concluded to be a factor of 10 less than Pasquill Class D. Analyses performed by the National Oceanic and Atmospheric Administration (Doty et al. 1976) confirm that this assumption is reasonable.

The overall probability of the consequence of an accident for each population area was then calculated by multiplying the accident probability times the consequence probability times the fraction of distance traveled. Starting with the highest consequences, the probabilities were then compared to the 1 x 10y6 per year criterion for the design basis accidents and 1 x 10y7 per year criterion for the beyond design basis accidents. If the probability was greater than 10 times the criterion (1 x 10y6 or 1 x 10y7), the most severe Pasquill Class F results were presented. If not, and the probability was greater than the criterion (1 x 10y6 or 1 x 10y7), Pasquill Class D was presented. If the probability was less than the cutoff, the probabilities having the next most severe consequences were compared to the same criterion and this step was repeated until all consequences were evaluated. As a minimum, the consequences resulting from release of 1% of the corrosion products (Pasquill Class D) were presented.

Careful attention was paid to ensure that the probabilities were not calculated for such small categories that the resulting probabilities were less than the criterion and results would inadvertently present less severe consequences. When the highest consequence accident did not meet the criterion, the probability of the next highest accident was determined by summing both the accident consequence being evaluated and the probability of the higher consequence accidents previously shown to have a probability less than the criterion. This same technique was applied to the fraction of travel (urban fraction is equivalent to highest consequence, suburban fraction is next highest, etc.) as demonstrated in the following example.

Probability of the accident of Consequence A - 1.17 x 10y7
Fraction of distance traveled in rural area - 0.85
Fraction of distance traveled in suburban area - 0.11
Fraction of distance traveled in urban area - 0.04

The urban fraction was multiplied by the probability, and the resultant probability of an accident of Consequence A in an urban area was 4.68 x 10y9. The consequences of this accident would not be evaluated. For the suburban area, the suburban and urban fractions were added and then multiplied by the probability (1.75 x 10y8). Again, the consequences of this accident would not be evaluated since the probability is less than 1 x 10y7. Likewise, for the rural area, the rural, suburban, and urban fractions were added and multiplied by the probability. Using this technique, the probabilities would indicate that the rural probability was 1.17 x 10y7, which is greater than the 1 x 10y7 criterion and the Consequence A results would be presented. If the fractions were used at face value, however, the probability of an accident of Consequence A would have been 4.68 x 10y9 in an urban area, 1.29 x 10y8 in a suburban area, and 9.95 x 10y8 in a rural area. When individually compared to the 1 x 10y7 criterion, this accident would not have been presented for any area.

Accident results are presented for both the maximum exposed individual and the general population. These results include members of the transportation crew.

A.6 ROUTING ANALYSIS

In order to assess the radiological risks associated with transportation, it was necessary to determine route characteristics based on the origin and destination of each shipment.

For naval spent nuclear fuel shipments, the origin is the prototype or shipyard location where the naval spent nuclear fuel is removed from a prototype or shipboard reactor. The destination is ECF, Savannah River Site, Hanford Site, Oak Ridge Reservation, Nevada Test Site, or Puget Sound Naval Shipyard, depending on the alternative. For each origin and destination pair, the potential rail routes have been generated and analyzed using the INTERLINE computer code (Johnson 1993a). For shipments originating from Pearl Harbor Naval Shipyard, the containers travel by ship to Puget Sound Naval Shipyard, where they are transferred to rail for shipment to the destination following the same routes as the naval spent nuclear fuel shipments originating from Puget Sound Naval Shipyard. The shipment travel time by ocean was based on historical data on the time in transit, independent of the actual route. For heavy-lift transporter shipments from the Kesselring and Windsor prototype sites to the closest rail siding, the actual street routes and shipment duration times based on previous shipments were used.

INTERLINE is an interactive computer program designed to simulate routing using the U.S. rail system. The INTERLINE code used is the latest available from Oak Ridge National Laboratory and contains the 1990 census data. The INTERLINE data base consists of networks representing various competing rail companies in the U.S. The routes used for the transportation evaluation use the standard INTERLINE model which simulates the selection procedure that railroad companies would use to direct shipments of spent nuclear fuel. The code is updated periodically to reflect current track conditions and has been benchmarked against reported mileages and observations. INTERLINE also provides the weighted population densities for rural, suburban, and urban populations for each state and averaged over all states along the shipment route and the percentage of mileage traveled in each population density. The distance traveled, weighted population density, and percentage of distance in each population density are input variables in the RADTRAN 4 code.

For the off-site transportation of the test specimen assemblies and test specimens, all shipments are made by exclusive-use truck which includes no other freight. The destinations are ECF, Savannah River Site, Hanford Site, Oak Ridge Reservation, Nevada Test Site, Puget Sound Naval Shipyard, Bettis Atomic Power Laboratory, and Knolls Atomic Power Laboratory for the various alternatives. For each origin and destination pair, the potential truck routes have been generated and analyzed using the routing model HIGHWAY.

HIGHWAY is an interactive computer code designed to simulate routing using the U.S. highway system. The HIGHWAY code used for this report is the latest available from Oak Ridge National Laboratory. The code is updated periodically as new roads are added. HIGHWAY provides the distance between the origin and destination, the weighted population densities along the route, and the percentage of distance traveled in each population density, all input variables for the RADTRAN 4 computer code.

For the on-site transportation, HIGHWAY only has two of the sites on the INEL. This origin/destination pair was run using HIGHWAY to determine the population densities and percentage of travel in each population density. The actual distance between sites on the INEL was measured.

A.7 INPUT PARAMETERS

The major input parameters and models used to evaluate the radiological risks associated with the five alternatives described in Section A.3 are provided in this section. Standard RADTRAN 4 computer code values, as well as actual data gathered from historical naval spent nuclear fuel and test specimen shipments, were used as the basis for the input parameters. For those situations where historical data were available, the actual data were used in place of the standard RADTRAN 4 computer code values to provide the best estimate of the radiological risks associated with each alternative.

A.7.1 Shipments of Naval Spent Nuclear Fuel from Shipyards and Prototypes

A.7.1.1 Incident-free Transportation of Spent Nuclear Fuel from Shipyards and Prototypes. This section provides the input parameters used to determine the radiological impacts associated with the routine, incident-free (i.e., no accident) transportation of spent nuclear fuel for each of the five alternatives.

A.7.1.1.1 Planned Shipments. The list of planned shipments of naval spent nuclear fuel by origin is provided in Table A-8.

Table A-8. Planned shipments of naval spent nuclear fuel from shipyards and prototypes.

Alternative	Generating Site East Coast	West Coast	NRF	TOTAL	Origin or Destination
No Action, Decentralization - No Exam	204	0	0	204	To Norfolk
Decentralization - Limited Exam	53	0	1	54	To Puget Sound
	181	0	0	181	To Norfolk
	234	0	1	235	
Decentralization - Full Exam	314	261	0	575	To ECF
	314	261	0	575	From ECF
	628	522	0	1150	
1992/1993 Planning Basis, Regionalization at INEL and Centralization at INEL	314	261	0	575	To ECF
All other Regionalization and Centralization Alternatives	314	261	3	578	To Regionalization or Centralization site

A.7.1.1.2 Transport Index. Historical information from prior shipments was used to estimate the expected external radiation exposure rates for future shipments. This information included actual measured radiation levels and the recorded Transport Indexes (TIs) from past shipments. The TI used in this analysis is the sum of the maximum neutron and gamma radiation measured at 1 meter (3.3 feet) from the surface of the cask. The TIs that were used ranged from 0.1 to 1.8.

A.7.1.1.3 Transportation Distances and Population Densities. Section A.6 provided a description of the general methodology used for determining transportation distances and the population densities along the transportation routes. Historical data were obtained on the distance traveled for shipments from the shipyards and prototype sites to ECF. These data were averaged by origin and compared to the value calculated by INTERLINE. The actual data were approximately 11% higher than the distance predicted by INTERLINE on average. In order to provide the best estimate exposure, which is based on the distance traveled, the INTERLINE distances were increased by 11% for the 1992/1993 Planning Basis alternative. One of the primary reasons the actual distances traveled were judged to be longer than the INTERLINE prediction was the escort responsibility to avoid potential delays due to track or security problems. The shipments to the alternative sites will also be escorted and therefore the same increased travel distance is expected. The 11% increase in distance traveled was also applied to all other alternatives. This technique allowed for comparison of the alternatives on an equal basis. The percentages of distance traveled in each population density calculated by INTERLINE were applied to the distances increased by 11%.

A.7.1.1.4 Train Speed. The RADTRAN 4 computer code provides standard values for train

speeds that are dependent on the population density. For rural areas, the standard value is 64.4 kilometers per hour (40 miles per hour (mph)). For suburban areas, the standard value is 40.2 kilometers per hour (25 mph), and for urban areas, the standard value is 24.1 kilometers per hour (15 mph). However, naval spent nuclear fuel shipments are required to be transported at speeds not to exceed 56.3 kilometers per hour (35 mph). Government escort logs from historical spent nuclear fuel shipments support use of 24.1 kilometers per hour (15 mph). This 24.1 kilometers per hour (15 mph) train speed estimate was used to evaluate all five alternatives.

A.7.1.1.5 Train Stop Time. The RADTRAN 4 computer code provides standard values for train

stop times that are either dependent or independent of the distances traveled. For naval spent nuclear fuel transported by rail, the government escorts are responsible for ensuring that the shipments are made in the most efficient and safe manner. The government escort logs for historical spent nuclear fuel shipments were reviewed, and actual stop times were determined to be much shorter than the standard RADTRAN 4 computer code values. The recorded stop times were divided by the actual distance traveled from historical data over the last 3 years and an average of 0.02 hour per kilometer (0.032 hour per mile) was calculated. This value was used to evaluate all five alternatives since the rail transportation of spent nuclear fuel will always be accompanied by government escorts and all alternatives originate from the same locations.

A.7.1.1.6 Number of Train Crew Members. The standard RADTRAN 4 computer code value for the

number of train crew members is five. For all shipments to NRF, all rail companies with the exception of Burlington Northern have two crew members during shipments, located in the locomotive. Burlington Northern adds a third crew member in a caboose immediately behind the government escort caboose. In the RADTRAN 4 computer code, exposure to the crew members is not calculated since the distance to the crew members is large. In actuality, the distance to the Burlington Northern crew member located in the caboose is less than that used in the RADTRAN 4 computer code and therefore simple calculations were performed to determine the radiological exposure. In addition, naval spent nuclear fuel shipments also are shipped periodically by "special train." In the special train configuration, the two crew members in the locomotive are one car from the railcar with the shipping container. Historically, these shipments occur approximately 42 percent of the time. The majority of shipments by "special" train are arranged by the railroad companies to meet railroad schedules. On occasion, the Navy requests "special" train service for shipments with high-priority examination material. Simple calculations were also performed to determine the radiological exposure during these special shipments. For shipments to the sites other than NRF, there was no experience with all railroad companies which would have to be used; however, there is no reason to expect the rail companies to change their standard practices. In these cases, there would be two train crewmen, both located in the engine area. Forty-two percent of the shipments would be shipped by special train to the alternate sites. When applicable, the third Burlington Northern crew member was also accounted for.

A.7.1.1.7 Transport Index to Exposure Rate Conversion Factors. Container transport index to exposure rate conversion factors for the M-130 and M-140 shipping containers were calculated using the standard equation in the RADTRAN 4 computer code. The results were compared to detailed computer analyses performed using SPAN4, and the RADTRAN 4 results were found to overestimate the exposure by a factor of two to three. Using the SPAN4 computer code results, the effective package dimensions of the containers used in the RADTRAN 4 calculations were adjusted to provide a conservative yet more realistic value of the transport index to exposure rate conversion factor. Due to similarities in the construction and fuel shipped, the M-130 conversion factor was applicable to the M-160. The values used are provided in Table A-9.

Table A-9. Transport index to exposure rate conversion factors for the M-130, M-140, and M-160 shipping containers.

Container	Effective Package Dimension (meters)	Transport Index to Exposure Rate Conversion Factor
M-130/M-160	2.50 (8.2 feet)	5.06
M-140	3.20 (10.5 feet)	6.76

A.7.1.1.8 Train Stop Shield Factors. For train stops, the standard RADTRAN 4 computer code gamma and neutron radiation shield factors are both assigned as 0.1. This value includes the presence of substantial railyard steel structures equivalent to approximately 4 inches of steel. Four inches of steel reduces gamma radiation by more than a factor of 10; however, the steel only reduces neutron radiation by a factor of approximately 2. Therefore, a shield factor of 0.5 was conservatively used for neutron radiation. In order to incorporate this shielding into the RADTRAN 4 computer code, separate gamma and neutron radiation exposure calculations were performed. However, since RADTRAN 4 does not permit separate shielding factors to be used for different types of radiation, the stop times for the neutron radiation evaluations were increased by a factor of 5 to provide an equivalent increase in neutron exposure. These more realistic changes to the standard RADTRAN 4 computer code values were incorporated for all five alternatives.

A.7.1.1.9 Radiation Exposure Decrease Due to Distance. The RADTRAN 4 computer code provides standard values for determining the gamma and neutron radiation exposure decrease at increasing distance from the source. For gamma radiation, the RADTRAN 4 computer code uses the 1/x2 decrease due to distance. The RADTRAN 4 computer code also specifically calculates the decrease in neutron exposure at increased distances. The adequacy of the RADTRAN 4 radiation exposure decrease was evaluated. The gamma radiation decrease factor used by RADTRAN 4 was consistent with the results predicted for naval fuel. The RADTRAN 4 prediction for neutron radiation slightly overpredicts the decrease in exposure at far distances for the shipping containers used for naval shipments.

Using the same basic equation used by RADTRAN, a value of 2.0 x 10y10 was used for the RADTRAN 4 constant a4 in lieu of 0. The value of 2 x 10y10 produces results which are slightly higher than the standard method and agree with measurements of neutron exposure rates from naval spent nuclear fuel shipments.

A.7.1.1.10 Shipment Storage Time. As noted previously, the government escorts accompanying the rail shipments of spent nuclear fuel are responsible for ensuring that the naval spent nuclear fuel shipments are made in the most efficient and safe manner. Naval spent nuclear fuel is not stored while being shipped; therefore, there was no intermediate shipment storage time associated with any of the alternatives. There is also no intermediate storage time during the heavy-lift transport shipments from the prototype sites and the ocean shipments from Pearl Harbor Naval Shipyard.

A.7.1.1.11 Heavy-lift Transporter Transportation Crew. Information from records of naval spent nuclear fuel shipments was reviewed to determine a realistic estimate of the number of people involved, the amount of time required, and the distances between individuals and the shipping container. The number of hours worked ranged from 1 to 10 and the distance from the container ranged from 1.5 to 91 meters (5 to 300 feet). For simplicity, weighted averages of the number of hours and distances from the shipping container were calculated and are provided in Table A-10.

Table A-10. Summary of the number of people involved and distance from the container during heavy-lift transporter shipments to the rail siding at the prototype sites.

Prototype	Number of People	Number of Hours per Worker	Distance from the Shipping Container (meters)
Windsor Site	37	5.08	25.0 (82 feet)
Kesselring Site	36	5.11	32.3 (106 feet)

This information was used to evaluate all five alternatives.

A.7.1.1.12 Time to Ship by Heavy-lift Transporter. Based on discussions with personnel at the prototype facilities who have made shipments and a review of records, the average duration of the heavy-lift transporter shipment from the prototype sites to the local rail siding is 2 hours.

A.7.1.1.13 Number of Heavy-lift Transporter Inspections. The shipments are inspected prior to leaving the prototype's site boundaries, and no additional inspections are performed during the short heavy-lift transporter shipment. As a result, there are no inspections during the heavy-lift transporter shipment in the evaluation of the five alternatives.

A.7.1.1.14 Heavy-lift Transporter Stop Time. Shipments of spent nuclear fuel from the two prototype locations are first transported by heavy-lift transporter to the nearest rail siding. Information from records of naval spent nuclear fuel shipments was reviewed to determine a realistic estimate of the heavy-lift transporter stop times. For naval spent nuclear fuel heavy-lift transporter shipment from the Windsor Site, a heavy-lift transporter stop time of 24 hours was used. For heavy- lift transporter shipments from the Kenneth A. Kesselring Site, a stop time of 10 hours was used. The heavy-lift transporter shipments from the prototypes to the rail sidings occur through suburban populations only. These heavy-lift transporter stop times were used to evaluate all five alternatives.

A.7.1.1.15 Standard RADTRAN 4 Computer Code Values Used. The following standard RADTRAN 4 computer code value was reviewed and determined to reflect the best estimate of current railroad industry practice:

- Number of Inspections of the Shipping Container and Railcar.

The following standard RADTRAN 4 computer code estimates of the populations that could be affected by the shipment of spent nuclear fuel were also used for the five alternatives:

- Number of People per Vehicle Sharing the Transport Route (On Link)
- Traffic Count Passing a Specific Point - Rural, Suburban, and Urban Zones
- Average Exposure Distance When Stopped
- Persons Exposed While Stopped
- Fraction of Travel During Rush Hour, on City Streets, and on Freeways.

A.7.1.1.16 Number of Ship Inspections. Shipments of spent nuclear fuel from Pearl Harbor Naval Shipyard must first be transported by ship to the Puget Sound Naval Shipyard. Using the standard values in the RADTRAN 4 computer code, the radiological exposures to the crew and government escorts are negligible since the distances from these individuals to the shipping containers are large. As a result, the radiological exposure estimates are only expected to occur during inspections. Based on radiation monitoring results for past naval spent nuclear fuel shipments, this is not realistic for naval spent nuclear fuel, and a separate calculational model was developed to account for this potential radiation exposure. The model uses the standard point source formula (see Section A.5.1) to calculate the crew and government escort exposures during transport by ship. The model took into account the ship used, transport index, transport time, distance between shipping containers, distance from the shipping containers and living quarters, distance from the shipping containers and the engine room, the number of crew members and government escorts, and the time required for inspections based on records from historical shipments of spent nuclear fuel. After reviewing historical shipment records, it was determined that three different sized ships have recently been used. The smallest one, Ship 1, was used once and is not expected to be used in the future. Only the other two, Ships 2 and 3, would be used in the future, in equal proportion. Table A-11 below provides the information used to calculate the radiological exposures resulting from transporting naval spent nuclear fuel by ship. This model was used to evaluate all five alternatives.

Table A-11. Parameters used to calculate crew and escort exposure during ocean travel from Pearl Harbor Naval Shipyard to Puget Sound Naval Shipyard.

Parameter	Ship 1	Ship 2	Ship 3
Transport Time, T, in days	11	8	9
Separation Between M-130s, X1, in feet	92	43	20
Nearest Distance to Living Quarters, X2, in feet	40	80	300
Nearest Distance to Engine Room, X3, in feet	20	80	300
Number of Crew Members, Nc	11	22	26
Number of Government Escorts (not part of crew size), Ne	2	2	2
Escort Inspection Time (per Escort), in hr/day	0.50 for historic 0.25 for future		
Shielding Factor	(1/3) for gamma, (2/3) for neutron, for every 40-foot increment		

from the container
centerline

A.7.1.2 Accident During Transportation of Spent Nuclear Fuel. This section provides the input parameters used to calculate the radiological impacts for accidents during transportation of spent nuclear fuel for evaluation of the five alternatives. The planned shipments, transportation distances, population densities, and the percentages of travel in each population density described in Section A.7.1.1 were also used for the accident analyses. Unless otherwise described in this section, the standard values provided by the RADTRAN 4 and RISKIND computer codes were used.

A.7.1.2.1 Accident Probability. The probability of a rail accident used for evaluation of all alternatives was obtained from "Longitudinal Review of State-Level Accident Statistics for Carriers of Interstate Freight" (Saricks and Kvitek 1994). The probabilities are provided both by state and a national average. The state dependent probabilities were used for the accident risk assessment. Past naval spent nuclear fuel shipments have traveled approximately 2 million kilometers (1.24 million miles) by rail without an accident, which is consistent with the national average of 5.57 x 10y8 accident per kilometer.

A.7.1.2.2 Accident Severity Categories and Probabilities. In the "Shipping Container Response to Severe Highway and Railway Accident Conditions" (NUREG 1987), referred to as the "Modal Study," Lawrence Livermore National Laboratory categorized the potential damage to shipping containers according to the magnitude of the thermal and mechanical forces that could result from an accident. The structural and thermal forces were categorized into 20 regions. Given that an accident occurs, the probability that the accident would be in each region was calculated for both rail and truck shipments. Table A-12 provides the probabilities for rail accidents by region.

Table A-12. Accident severity probabilities for rail shipments.

	R(4,1) 1.786 x 10y9	R(4,2) 3.290 x 10y13	R(4,3) 2.137 x 10y13	R(4,4) 1.644 x 10y13	R(4,5) 3.459 x 10y14
S3 (30)	R(3,1) 5.545 x 10y4	R(3,2) 1.0217 x 10y7	R(3,3) 0.634 x 10y8	R(3,4) 5.162 x 10y8	R(3,5) 5.296 x 10y8
S2 (2)	R(2,1) 2.7204 x 10y3	R(2,2) 5.011 x 10y7	R(2,3) 3.255 x 10y7	R(2,4) 2.531 x 10y7	R(2,5) 1.075 x 10y8
S1 (0.2)	R(1,1) 0.993962	R(1,2) 1.2275 x 10y3	R(1,3) 7.9511 x 10y4	R(1,4) 6.140 x 10y4	R(1,5) 1.249 x 10y4
				T4 (1050)	

Thermal Response (lead mid-thickness temperature, yF)

A.7.1.2.3 Naval Spent Nuclear Fuel Integrity Following an Accident. Detailed structural and thermal analyses were performed for the shipping containers used for naval spent nuclear fuel shipments up to an equivalent strain of 30% and mid-wall temperature of 1050yF. For these cases, the naval spent nuclear fuel was not damaged. For the thermal and structural regions above 1050yF and 30% strain, the modal study defines the upper limits as unbounded. The naval spent nuclear fuel was postulated to be damaged and the fission products and corrosion products would be released in the quantities described in

Table A-13 for the risk analyses.

A.7.1.2.4 Release Fractions. The release fractions were derived based on the results presented in the NRC modal study (NUREG 1987) and the results of the structural and thermal analyses described above. Although the naval spent nuclear fuel is stronger, the release fractions for the boiling water reactor (BWR), pressurized water reactor (PWR), and aluminum-clad fuel from the modal study were used. From the modal study, the release fraction in lower left region R(1,1) is zero for the risk evaluation. For the maximum consequence evaluation, 1% of the corrosion products might be released for the lower left region, R(1,1). Based on the results of the structural and thermal analyses up to 30% strain and 1050yF mid-wall temperature, the naval spent nuclear fuel is not damaged; therefore, regions R(1,2), R(1,3), R(2,1), R(2,2), R(2,3), R(1,4), R(2,4), R(3,4), R(3,1), R(3,2) and R(3,3) do not release fission products. Ten percent of the corrosion products might be released. In the remaining regions, 10% of the fission products might be available for release and released at the fractions specified below, also using a release of 10% of the corrosion products. Table A-13 provides the release fractions used.

Table A-13. Cask release fractions used for the RADTRAN 4 risk analyses.

	Release Fraction[a]					
Cask Response Region	Inert Gas	Iodine	Cesium	Ruthenium	Particulates	Corrosion Products
R(1,1)	0.0	0.0	0.0	0.0	0.0	0.0
R(1,2), R(1,3)	0.0	0.0	0.0	0.0	0.0	1.0
R(2,1), R(2,2), R(2,3)	0.0	0.0	0.0	0.0	0.0	1.0
R(1,4), R(2,4), R(3,4)	0.0	0.0	0.0	0.0	0.0	1.0
R(3,1), R(3,2), R(3,3)	0.0	0.0	0.0	0.0	0.0	1.0
R(1,5), R(2,5), R(3,5) R(4,5), R(4,1), R(4,2) R(4,3), R(4,4)	6.3 x 10y1	4.3 x 10y2	2.0 x 10y3	4.8 x 10y4	2.0 x 10y5	1.0

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[a] The release fraction represents the fraction of the fuel inventory available for release in the shipping container that would be released into the atmosphere following an accident of the given severity.

A.7.1.2.5 Plume Release Height. For the accident risk assessment, a ground level release was used. For the maximum consequence assessment, a plume release height of 10 meters (32.8 feet) was used.

A.7.1.2.6 Direct Exposure from a Damaged Shipping Container. A radiation level following the accident at the 10CFR71 regulatory limit of 1 rem at 1 meter (3.3 feet) from the container surface was used.

A.7.1.2.7 Food Transfer Factors. Food transfer factors were derived for the isotopes related to naval spent nuclear fuel in accordance with the methods described in Nuclear Regulatory Commission Guide 1.109 (NUREG 1977).

A.7.1.2.8 Distance from the Accident Scene to the Maximum Exposed Individual. No shielding

was accounted for as the plume passes for the calculation of the exposure to the maximum individual. This location was determined using RISKIND based on the atmospheric stability and plume release height used.
The maximum exposed individual could be a member of the rail crew or the general population.

A.7.1.2.9 RISKIND Population Density. The standard national average for each population

density from the RADTRAN 4 computer code was used for the RISKIND maximum consequences assessment (6 people per square kilometer for rural, 719 for suburban, and 3861 for urban).

A.7.1.2.10 Radionuclide Inventory. The amount of radionuclides which would be released from

an average shipment are provided in Table A-14. The values factor in the damage fraction described in Section A.7.1.2.3 and release fractions described in Section A.7.1.2.4. The radionuclides listed result in 99 percent of the exposure in all pathways.

Table A-14. Radionuclides which would be released from an average shipment of naval spent nuclear fuel from a shipyard or prototype.

For Accidents which Release Both Fission and Corrosion Products		For Accidents which Release Only Corrosion Products	
Nuclide	Activity (Ci)	Nuclide	Activity (Ci)
Kr-85	9.85 x 102	Co-58	1.61 x 10y1
Cs-134	3.72 x 101	Mn-54	2.22 x 10y2
Cs-137	3.44 x 101	Fe-55	6.62 x 10y1
H-3	1.39 x 101	Co-60	3.63 x 10y1
Ru-106	9.02 x 10y1	Sr-90	3.14 x 10y4
Ce-144	4.89 x 10y1	Ni-63	1.19 x 10y1
Co-60	3.63 x 10y1		
Sr-90	3.41 x 10y1		
Pu-238	1.02 x 10y2		
Pu-241	3.43 x 10y3		
Cm-244	1.36 x 10y4		

A.7.2 Transfers of Naval Spent Nuclear Fuel to Storage Following

Examination

A.7.2.1 Incident-free Transportation of Naval Spent Nuclear Fuel to Storage. This section provides the

input parameters used to determine the radiological impacts associated with the routine, incident-free (i.e., no accident) transportation of naval spent nuclear fuel to storage for each of the five alternatives.

A.7.2.1.1 Planned Shipments. Table A-15 provides the number of planned transfers in each cask.

Table A-15. Planned transfers of naval spent nuclear fuel to storage.

	NFS-100	Peach Bottom	Large Cell
No Action,	0	0	15
Decentralization - No Exam,			
Decentralization - Limited Exam			
Decentralization - Full Exa	0	0	14
1992/1993 Planning Basis,	196	64	468

All Regionalization Alternatives,
All Centralization Alternatives

A.7.2.1.2 Transport Index (TI). A TI of 0.3 was used for all NFS-100 cask transfers. This value was determined from recorded measurements over the last 3 years for the same fuel types planned to be transferred in the future. The Peach Bottom and Large Cell casks have not previously been used for the planned transfers and therefore historic data were not available. Based on a comparison of predicted TI values from conservative safety analyses to the actual measured TI's for similar casks and fuel types, a TI of 1.0 was calculated for both the Peach Bottom and Large Cell casks.

A.7.2.1.3 Transportation Distances and Population Densities. Section A.6 provided a description of the general methodology used for determining transportation distances and the population densities along the transportation routes. The distance between ECF and ICPP is 9.7 kilometers (6 miles). From the HIGHWAY computer code, the transfer of naval spent nuclear fuel to storage occurs in a rural area. As stated in Section A.3.5, the storage facility at the alternative sites was identical to ICPP. Therefore, for the evaluation of the alternatives, the distance traveled and population density of the ECF to ICPP transfer were also used for the evaluation of the other alternatives.

A.7.2.1.4 Truck Speed. The standard RADTRAN 4 computer code speed for truck shipments in a rural population is 88.5 kilometers per hour (55 miles per hour). One of the reasons an on-site worst credible accident is less severe than the 10CFR71 hypothetical accident is that the speed is severely limited by the on-site transportation procedures. An average speed of 24.1 kilometers per hour (15 miles per hour) was used.

A.7.2.1.5 Truck Stop Time. The standard RADTRAN 4 computer code provides values for truck stop times that are either dependent or independent of the distances traveled. The logs for historical transfers of naval spent nuclear fuel to storage were reviewed, and it was determined that the actual stop times (10 minutes) were much shorter than the standard RADTRAN 4 computer code values. A stop time of 10 minutes was used to evaluate all five alternatives.

A.7.2.1.6 Radiation Exposure Decrease Due to Distance. The radiation exposure decrease due to distance described in Section A.7.1.1.9 was also applied to the truck transfers of naval spent nuclear fuel to storage.

A.7.2.1.7 Distance from Source to Crew. A distance of 6.1 meters (20 feet) was measured between the shipping cask and the driver for the exclusive-use truck transfers of naval spent nuclear fuel shipments to storage. Two escorts, one located approximately 46 meters (150 feet) in front and one the same distance behind the transport vehicle, are also present. These data were used in the

RADTRAN analyses for all alternatives.

A.7.2.1.8 Transport Index to Exposure Rate Conversion Factors. Transport index to exposure rate conversion factors for the casks used for transfers of naval spent nuclear fuel to storage were calculated using the standard equation in RADTRAN 4. The results were compared to detailed computer analyses performed using SPAN4, and RADTRAN 4 results were found to overestimate the exposure. Using the SPAN4 computer code results, the effective package dimensions of the casks used in the RADTRAN 4 calculations were adjusted to provide a conservative yet more realistic value of the transport index to exposure rate conversion factor. The values used are provided in Table A-16.

Table A-16. Transport index to exposure rate conversion factors for the NFS-100, Peach Bottom, and Large Cell casks.

Cask	Effective Package Dimens (meters)	Transport Index to Exposure Rate Conversion Factor
NFS-100	3.8 (12.5 feet)	8.41
Peach Bottom	2.8 (9.2 feet)	5.76
Large Cell	3.2 (10.5 feet)	6.76

A.7.2.1.9 Storage. There is no intermediate storage time during transfers of naval spent nuclear fuel to its destination.

A.7.2.1.10 Persons Exposed While Stopped. The only stop time for the transfer of naval spent nuclear fuel to storage occurs during routine surveys at the destination entrance. This area is well removed from highway and general population and therefore no people were considered to be exposed during the short 10-minute stop. The escorts are not present during the surveys and the driver remains in the cab of the truck, 6.1 meters (20 feet) from the cask during the surveys. The people performing the surveys are badged and all exposure received during the surveys is included in the normal occupational exposure which is regularly monitored.

A.7.2.1.11 Traffic Count Passing a Specific Point. The RADTRAN 4 computer code uses 470 vehicles per hour passing the transport vehicle. Travel on the transport path is restricted to INEL employees by a security checkpoint, the majority of INEL employees ride the INEL site buses to work, and the transfers are not made during high traffic times (i.e., shift changes when buses are in service); therefore, using the standard 470 vehicles per hour value would be extremely conservative. A more realistic estimate of 25 vehicles per hour was used.

A.7.2.1.12 Standard RADTRAN 4 Computer Code Values Used. The following standard RADTRAN 4 computer code value was reviewed and determined to reflect the best estimate of current industry practice and was consistent with historical data from transfers of naval spent nuclear fuel to storage:

- Minimum Number of Inspections.

The following standard RADTRAN 4 estimate of the population that could be affected by the transfer of naval spent nuclear fuel to storage was used to evaluate the five alternatives:

- Number of People per Vehicle Sharing the Transport Route (On Link).

A.7.2.2 Accident During Transportation of Spent Nuclear Fuel to Storage. This section provides the

input parameters used to calculate the radiological impacts for accidents during transportation of spent nuclear fuel to storage for evaluation of the five alternatives. The planned transfers, transportation distances, population densities, and the percentages of travel in each population density described in Section A.7.2.1 were also used for the accident analyses. Unless otherwise described in this section, the standard values provided by the RADTRAN 4 and RISKIND computer codes were used.

A.7.2.2.1 Accident Probability. The probability of a truck accident used for evaluation of all

alternatives was obtained from "Longitudinal Review of State-Level Accident Statistics for Carriers of Interstate Freight" (Saricks and Kvitek 1994). The truck accident rates are state dependent. The states in which naval spent nuclear fuel would be transferred to storage for the alternatives described in Section A.3 are Idaho, Washington, South Carolina, Tennessee, and Nevada. The corresponding accident rates for travel on rural interstates in accidents per kilometer are 2.30 x 10y7 for Idaho, 2.50 x 10y7 for Washington, 1.83 x 10y7 for South Carolina, 1.48 x 10y7 for Tennessee, and 1.57 x 10y7 for Nevada. The values correspond to 3.70 x 10y7 (Idaho), 4.02 x 10y7 (Washington), 2.94 x 10y7 (South Carolina), 2.38 x 10y7 (Tennessee), and 2.53 x 10y7 (Nevada) accidents per mile.

A.7.2.2.2 Accident Severity Categories and Probabilities. In the modal study, Lawrence

Livermore National Laboratory categorized the potential damage to shipping containers according to the magnitude of the thermal and mechanical forces that could result from an accident. The structural and thermal forces were categorized into 20 regions. Given that an accident occurs, the probability that the accident would be in each region was calculated for both rail and truck shipments. Table A-17 provides the probabilities for truck accidents by region.

Table A-17. Accident severity probabilities for truck shipments.

	R(4,1)	R(4,2)	R(4,3)	R(4,4)	R(4,5)
	1.532 x 10y7	3.926 x 10y14	1.495 x 10y 1	7.681 x 10y16	<1 x 10y16
S3	R(3,1)	R(3,2)	R(3,3)	R(3,4)	R(3,5)
(30)	1.7984 x 10y3	1.574 x 10y7	2.034 x 10y7	1.076 x 10y7	4.873 x 10y8
S2	R(2,1)	R(2,2)	R(2,3)	R(2,4)	R(2,5)
(2)	3.8192 x 10y3	2.330 x 10y7	3.008 x 10y7	1.592 x 10y7	7.201 x 10y8
S1	R(1,1)	R(1,2)	R(1,3)	R(1,4)	R(1,5)
(0.2)	0.994316	1.687 x 10y5	2.362 x 10y5	1.525 x 10y5	9.570 x 10y6
	T1 (500)	T2 (600)	T3 (650)	T4 (1050)	

Thermal Response (lead mid-thickness temperature, yF)

A.7.2.2.3 Naval Spent Nuclear Fuel Integrity Following an Accident. Detailed structural and

thermal analyses have been performed for the casks used for shipments of naval spent nuclear fuel to storage. As described in Section A.4.5, these analyses are performed using a worst credible accident which is defined based on the site specific terrain and administrative controls during the short onsite shipment.

The probability of the worst credible accident is equal to that listed in region R(1,1). For accident conditions in excess of the worst credible accident, the fission product and corrosion product release fractions described in the next section were used.

A.7.2.2.4 Cask Release Fractions. The cask release fractions were derived based on the results

presented in the NRC modal study (NUREG 1987). Although the naval spent nuclear fuel is stronger, the release fractions for the BWR, PWR, and aluminum-clad fuel from the modal study were used. From the modal study, the release fraction for lower left region R(1,1) is zero for the risk evaluation. For the maximum consequence evaluation, 1% of the corrosion products were released for the lower left region, R(1,1). The remaining regions used 10% of the fission products available for release, released at the fractions specified below, and release of 10% of the corrosion products. Table A-18 provides the release fractions used. The release fractions in Table A-18 for the less severe conditions differ from those in Table A-13 because supplementary structural and thermal analyses have not been performed for the casks discussed in this section.

Table A-18. Cask release fractions used for the RADTRAN 4 risk analyses.

	Release Fraction[a]					
Cask Response Region	Inert Gas	Iodine	Cesium	Ruthenium	Particulates	Corrosion Products
R(1,1)	0.0	0.0	0.0	0.0	0.0	0.0
R(1,2), R(1,3)	9.9 x 10y3	7.5 x 10y5	6.0 x 10y6	8.1 x 10y7	6.0 x 10y8	1.0
R(2,1), R(2,2), R(2,3)	3.3 x 10y2	2.5 x 10y	4 2.0 x 10y5	2.7 x 10y6	2.0 x 10y7	1.0
R(1,4), R(2,4), R(3,4)	3.9 x 10y1	4.3 x 10y3	2.0 x 10y4	4.8 x 10y5	2.0 x 10y6	1.0
R(3,1), R(3,2), R(3,3)	3.3 x 10y1	2.5 x 10y3	2.0 x 10y4	2.7 x 10y5	2.0 x 10y6	1.0
R(1,5), R(2,5), R(3,5) R(4,5), R(4,1), R(4,2) R(4,3), R(4,4)	6.3 x 10y1	4.3 x 10y2	2.0 x 10y3	4.8 x 10y4	2.0 x 10y5	1.0

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a The release fraction represents the fraction of the fuel inventory available for release in the cask that would be released into the atmosphere following an accident of the given severity.

A.7.2.2.5 Plume Release Height. For the accident risk assessment, a ground level release was

used. For the maximum consequence assessment, a plume release height of 10 meters (32.8 feet) was used.

A.7.2.2.6 Direct Exposure from a Damaged Shipping Container. A radiation level following the

accident at the 10CFR71 regulatory limit of 1 rem at 1 meter (3.3 feet) from the cask surface was used.

A.7.2.2.7 Food Transfer Factors. Food transfer factors were derived for the isotopes related to

naval spent nuclear fuel in accordance with the methods described in Nuclear Regulatory Commission Guide 1.109 (NUREG 1977).

A.7.2.2.8 Distance from the Accident Scene to the Maximum Exposed Individual. No shielding

was accounted for as the plume passes for the calculation of the exposure to the maximum individual. This location was determined using RISKIND based on the selected atmospheric stability and plume release height. The maximum exposed individual could be a member of the track crew or the general population.

A.7.2.2.9 RISKIND Population Density. From the HIGHWAY computer code, the population

density for the on-site shipment was determined to be one person per square kilometer (2.6 persons per square mile) in a rural area. For on-site transportation at INEL, the population density in the most populated sector, from 1990 census data, is 55 people per square kilometer, with the majority of these people in the area 64.4 to 80 kilometers (40 to 50 miles) from the site. This population density is just into the lower region of the suburban density range of 53.7 to 1284.7 people per square kilometer (139 to 3326 people per square mile) used in HIGHWAY and INTERLINE. The standard value of 6 (rural) and 719 (suburban) people per square kilometer (15.5 and 1861 people per square mile, respectively) was used for the evaluation of all alternatives.

A.7.2.2.10 Radionuclide Inventory. The transfers of naval spent nuclear fuel to storage contain

the same radionuclides as listed in Table A-14. On average, there is approximately 80 percent of the activity of each radionuclide.

A.7.3 Transfers of Naval Test Specimen Assemblies Between the

Examination Facility and the Test Reactor Area

A.7.3.1 Incident-free Transportation of Naval Test Specimen Assemblies. This section provides the

input parameters used to determine the radiological impacts associated with the routine, incident-free (i.e., no accident) transportation of naval test specimen assemblies for each of the five alternatives.

A.7.3.1.1 Planned Shipments. Table A-19 provides the number of planned transfers in each cask.

Table A-19. Planned transfers of naval test specimen assemblies.

	NR/ATR	Test Train
No Action, Decentralization - No Exam, Decentralization - Limited Exam	0	0
Decentralization - Full Exam 1992/1993 Planning Basis, Regionalization at INEL, and Centralization at INEL	38	922
All other Regionalization and Centralization Alternatives	0	960

A.7.3.1.2 Transport Index. A TI of 130.0 was used for all NR and ATR cask transfers. This

value was derived from historic measurements over the last several years. The new Test Train casks, which are currently being designed, would have a TI of 1.0.

A.7.3.1.3 Transportation Distances and Population Densities. Section A.6 provided a

description of the general methodology used for determining transportation distances and the population densities along the transportation routes. The distance between ECF and TRA is 8.0 kilometers (5 miles). From the HIGHWAY computer code, this on-site transfer of naval test specimen assemblies occurs in a rural area. For shipments from TRA to the centralization sites, the HIGHWAY computer code was used to calculate the distance traveled, the population densities, and the percent distance traveled in each population density. As described in Section A.7.4.1.3, the HIGHWAY predicted distances for off-site shipments were increased by 3%.

A.7.3.1.4 Truck Speed. The standard RADTRAN 4 computer code speed for truck shipments in a

rural population is 88.5 kilometers per hour (55 miles per hour). One of the reasons an on-site worst credible accident is less severe than the 10CFR71 hypothetical accident is that the speed is severely limited. An average speed of 16.1 kilometers per hour (10 miles per hour) was used for the on-site shipments. For off-site shipments to the centralization sites, the standard RADTRAN 4 computer code values were used.

A.7.3.1.5 Truck Stop Time. The standard RADTRAN 4 computer code provides values for truck

stop times that are either dependent or independent of the distances traveled. The logs for historical on-site transfers of naval test specimen assemblies were reviewed, and it was determined that the actual stop time (one and one-half hours) was less than the standard RADTRAN 4 computer code values. For the alternative in which on-site transfers would continue, the one and one-half hour stop time was used. For the off-site shipments of test specimen assemblies to the centralization sites, a stop time of 0.006 hour per kilometer (0.01 hour per mile) was used, consistent with the value used for other past truck shipments outside the boundaries of DOE facilities (see Section A.7.4.1.4).

A.7.3.1.6 Radiation Exposure Decrease Due to Distance. The radiation exposure decrease due to

distance described in Section A.7.1.1.9 was also applied to the truck transfers of test specimen assemblies.

A.7.3.1.7 Distance from Source to Crew. A distance of 3.6 meters (12 feet) was measured

between the NR/ATR shipping cask and the driver for the exclusive-use truck transfers of test specimen assemblies on-site. Two escorts, one located approximately 46 meters (150 feet) in front and one the same distance behind the transport vehicle, are also present for on-site shipments.

For off-site shipments to the centralization sites, the standard RADTRAN 4 computer code value for the number of crew members was used (2). The value used for the distance from the crew to the centerline of the cask for off-site shipments was 5.85 meters (20 feet), based on the conceptual design of the new Test Train cask.

A.7.3.1.8 Transport Index to Exposure Rate Conversion Factors. Transport index to exposure

rate conversion factors for the casks used for test specimen assembly transfers were calculated using the standard equation used by RADTRAN 4. The results were compared to detailed computer analyses performed using SPAN4, and RADTRAN 4 results were found to overestimate the exposure. Using the SPAN4 computer code results, the effective package dimensions of the casks used in the RADTRAN 4 calculations were adjusted to provide a conservative yet more realistic value of the transport index to exposure rate conversion factor. The values used are provided in Table A-20.

Table A-20. Transport index to exposure rate conversion factors for the NR/ATR and Test Train casks.

Cask	Effective Package Dimension (meters)	Transport Index to Exposure Rate Conversion Factor
NR/ATR	0.61 (2 feet)	1.70
Test Train	1.70 (5.6 feet)	3.42

A.7.3.1.9 Storage. There is no intermediate storage time during transfers of naval test specimen

assemblies.

A.7.3.1.10 Persons Exposed While Stopped. The only stop time for the transfer of naval test

specimen assemblies on-site occurs during routine surveys at the destination entrance. This area is well removed from highway and population and therefore no people were considered to be exposed during the one and one-half hour stop. The escorts are not present during the surveys and the driver is positioned approximately 46 meters (150 feet) from the source during the surveys. The people performing the surveys are badged and all exposure received during the survey is included in the normal occupational exposure which is regularly monitored. For off-site shipments, the standard RADTRAN 4 computer code values were used.

A.7.3.1.11 Traffic Count Passing a Specific Point. The RADTRAN 4 computer code uses 470

vehicles per hour passing the transport vehicle. Travel on the on-site transport path is restricted to INEL employees, the majority of INEL employees ride the INEL site buses to work, and the transfers are not made during high traffic times (i.e., shift changes); therefore, using the standard 470 vehicles per hour value would excessively overestimate the number of persons involved. A more realistic estimate of 25 vehicles per hour was used for on-site shipments. For off-site shipments, the standard RADTRAN 4 computer code values were used.

A.7.3.1.12 Standard RADTRAN 4 Computer Code Values Used. The following standard RADTRAN 4

computer code value was reviewed and determined to reflect the best estimate of current industry practice and was consistent with recorded data from transfers of naval test specimen assemblies:

- Minimum Number of Inspections.

The following standard RADTRAN 4 estimate of the population that could be affected by the transfer of test specimen assemblies was used for evaluation of the five alternatives:

- Number of People per Vehicle Sharing the Transport Route (On Link).

A.7.3.2 Accident During Transportation of Naval Test Specimen Assemblies. This section provides the

input parameters used to calculate the radiological impacts for accidents during transportation of naval test specimen assemblies for evaluation of the five alternatives. The planned transfers, transportation distances, population densities, and the percentages of travel in each population density described in Section A.7.3.1 were also used for the accident analyses. Unless otherwise described in this section, the standard values provided by the RADTRAN 4 and RISKIND computer codes were used. All variables described in Section A.7.2.2 are applicable to these transfers with the exception of the RISKIND population density.

A.7.3.2.1 RISKIND Population Densities. For the Decentralization, 1992/1993 Planning Basis,

Regionalization at INEL, and Centralization at INEL alternatives, the test specimen assembly transfers would occur on the INEL site. For these transfers, the same conditions described in Section A.7.2.2.9 were used. For the other Regionalization and Centralization alternative risk assessments, the population densities from RADTRAN 4 were used.

A.7.3.2.2 Release Fractions. For the Decentralization, 1992/1993 Planning Basis, and

Regionalization at INEL, and Centralization at INEL alternatives, the test specimen assembly transfers would occur on the INEL site. For these transfers, the same conditions described in Sections A.7.2.2.3 and

A.7.2.2.4 were used. For the other Regionalization and Centralization alternatives, the conditions

described in Sections A.7.1.2.3 and A.7.1.2.4 were used.

A.7.3.2.3 Radionuclide Inventory. The radionuclides which would be released from an average

transfer are listed in Table A-21, along with the activity. The values factor in the damage fractions and release fractions described in Section A.7.3.2.2. The radionuclides listed result in 99 percent of the exposure in each pathway.

Table A-21. Radionuclides which would be released from an average transfer of test specimen assemblies.

For Accidents which Release Both Fission and Corrosion Products		For Accidents which Release Only Corrosion Products	
Nuclide	Activity (Ci)	Nuclide	Activity (Ci)
I-131	1.30 x 103	Eu-156	3.75 x 101
H-3	3.51 x 102	Lu-177	1.59 x 101
I-132	3.10 x 102	Eu-152	1.41 x 101
Eu-156	3.75 x 101	Zr-95	1.07 x 101
Eu-152	1.41 x 101	Zn-65	9.80 x 100
Zr-95	1.09 x 101	Co-60	7.68 x 100
Zn-65	9.80 x 100	Ce-141	6.60 x 100
Co-60	7.68 x 100	Eu-154	6.15 x 100
Eu-154	6.15 x 100	Cs-136	4.69 x 100
Sc-46	3.25 x 100	Sc-46	3.25 x 100
Cs-137	1.78 x 100	I-131	2.37 x 100
Ru-106	3.36 x 10y1	Hf-181	2.35 x 100
Nb-95	2.64 x 10y1		
Pr-144	2.19 x 10y1		
Ce-144	2.19 x 10y1		

A.7.4 Shipments of Naval Irradiated Test Specimens to Examination

and Testing Facilities

A.7.4.1 Incident-free Transportation of Test Specimens. This section provides the input parameters used to determine the radiological impacts associated with the routine, incident-free (i.e., no accident) transportation of test specimens for evaluation of the five alternatives.

A.7.4.1.1 Planned Shipments. Table A-22 provides the estimated number of shipments used in the analysis.

Table A-22. Planned shipments of naval test specimens.

	NRBK-41/WAPD-40				
Alternative	ICPP	PSNS	Centralization Site	BETTIS	KAPL
No Action	29	0	0	0	320
Decentralization - No Exam					
Decentralization - Limited Exam	26	3	0	0	320
Decentralization - Full Exam	0	0	0	0	320
1992/1993 Planning Basis, Regionalization at INEL, and Centralization at INEL Alternatives	0	0	0	120	641
All other Regionalization and Centralization Alternatives	0	0	29	120	641

A.7.4.1.2 Transport Index. A TI of 0.1 was used for all NRBK-41 and WAPD-40 shipping container shipments. These values were derived from recorded measurements over the last several years.

A.7.4.1.3 Transportation Distances and Population Densities. Section A.6 provided a description of the general methodology used for determining transportation distances and the population densities along the transportation routes. Historical data were obtained for shipments of test specimens. The distance traveled was averaged based on the point of origin and compared to the value calculated by HIGHWAY. The actual distance traveled was approximately 3% higher on the average. In order to provide the best estimate exposure, which is based on the distance traveled, the HIGHWAY distances were increased by 3% for all alternatives. This technique allowed for comparison of the alternatives on an equal basis. The percentages of distance traveled in each population density calculated by HIGHWAY applied to the distances which were increased by the 3%.

A.7.4.1.4 Truck Stop Time. The RADTRAN 4 computer code provides standard values for truck stop times that are either dependent or independent of the distances traveled. The shipping logs for historical test specimen shipments were reviewed, and it was determined that the actual stop times were much shorter than the standard RADTRAN 4 computer code values. The recorded stop times were divided by the actual distance traveled from historical data over the last three years and an average of 0.006 hour per kilometer (0.01 hour per mile) was calculated. This value was used to evaluate all five alternatives.

A.7.4.1.5 Radiation Exposure Decrease Due to Distance. The radiation exposure decrease due to distance described in Section A.7.1.1.9 was also applied to the truck shipments of test specimens.

A.7.4.1.6 Transport Index to Exposure Rate Conversion Factors. Container transport index to exposure rate conversion factors for the casks used for test specimen shipments were calculated using the standard equation used by RADTRAN 4. The results were compared to detailed computer analyses performed using SPAN4, and RADTRAN 4 results were found to overestimate the exposure. Using the SPAN4 computer code results, the effective package dimensions of the containers used in the RADTRAN 4 calculations were adjusted to provide a conservative yet more realistic value of the transport index to exposure rate conversion factor. The values used are provided in Table A-23.

Table A-23. Transport index to exposure rate conversion factors for the NRBK-41 and WAPD-40 shipping containers.

Container	Effective Package Dimens (meters)	Transport Index to Exposure Rate Conversion Factor
NRBK-41	0.74 (2.4 feet)	1.88
WAPD-40	3.2 (10.5 feet)	6.76

A.7.4.1.7 Storage. The test specimen shipping containers are not stored during shipment.

A.7.4.1.8 Standard RADTRAN 4 Computer Code Values Used. The following standard RADTRAN 4 computer code values were reviewed and were determined to reflect the best estimate of current industry practice and were consistent with historical data from shipments of naval test specimens:

- Truck Speed
- Distance from Source to Crew
- Number of Crewmen
- Minimum Number of Inspections.

The following standard RADTRAN 4 estimates of the populations that could be affected by the shipment of test specimens were also used to evaluate the five alternatives:

- Persons Exposed While Stopped
- Average Exposure Distance While Stopped
- Number of People per Vehicle Sharing the Transport Route (On Link)
- Traffic Count Passing a Specific Point - Rural, Suburban, and Urban Zones
- Fraction of Travel During Rush Hour, on City Streets, and on Freeways.

A.7.4.2 Accident During Transportation of Test Specimens. This section provides the input parameters used to calculate the radiological impacts for accidents during transportation of test specimens to evaluate the five alternatives. The planned shipments, transportation distances, population densities, and the percentages of travel in each population density described in Section A.7.4.1 were also used for the accident analyses. Unless otherwise described in this section, the standard values provided by the RADTRAN 4 and RISKIND computer codes were used. All the conditions and variables described in Section A.7.1.2 are applicable to these shipments with the exception of the Accident Probability.

A.7.4.2.1 Accident Probability. The probability of a truck accident used for evaluation of all alternatives was obtained from "Longitudinal Review of State-Level Accident Statistics for Carriers of Interstate Freight" (Saricks and Kvitek 1994). The truck accident rates are state dependent. The states in which naval spent nuclear fuel would be shipped to storage for the alternatives described in Section A.3 were obtained from HIGHWAY. The accident rate values are consistent with past test specimen shipments which have traveled approximately 2.4 million kilometers (1.5 million miles) without an accident.

A.7.4.2.2 Test Specimen Integrity Following an Accident. Detailed structural and thermal

analyses were performed for the shipping containers used for naval test specimen shipments up to an equivalent strain of 30% and mid-wall temperature of 1050yF. For these cases, the sealed inner container was not damaged; therefore, only the activity on the outside of the inner container, which would be corrosion products, was released. For the thermal and structural regions above 1050yF and 30% strain, the modal study defines the upper limits as unbounded. For these cases, the sealed inner container holding the test specimens was postulated to be damaged and the fission products and corrosion products would be released in the quantities described in Section A.7.1.2.4.

A.7.4.2.3 Radionuclide Inventory. The test specimen shipments contain the same radionuclides

as listed in Table A-21. On average, there is approximately 1.5 percent of the activity of each nuclide.

A.8 SUMMARY OF RESULTS

A.8.1 Historical - Incident Free

This section summarizes the results of the calculations for the radiological and non-radiological impacts of the incident-free transportation of naval spent nuclear fuel and test specimens. Table A-24 shows the radiological impact on the general population, transportation workers (occupational), and the maximum exposed individual, and the non-radiological impact on all persons. The radiological impact on the general population for all historical shipments is 1.95 person-rem, which statistically corresponds to 0.00098 cancer fatalities in the entire population over the 40-year period considered. The radiological impact on transportation workers for all historical shipments is 16.6 person-rem, which statistically corresponds to 0.0066 cancer fatalities. As can be seen from Table A-24, the radiological impact to the general population is greatest for the highway transportation of test specimens. Incident-free radiological impacts tend to be greater for highway transportation than for rail transportation since both the general population and transportation workers are closer to the shipping container in transit. In all cases, the maximum exposed individual is a transportation worker, since the workers are closer to the shipment for a longer time than any member of the general population. The maximum exposed individual for all shipments is a driver for the trucks transferring test specimen assemblies between ECF and TRA. Under the limiting modeling approach that the same person drove every shipment for the entire period, this person received a total exposure of 7.5 rem over the approximate 40-year period, or about 0.19 rem per year, which is within DOE limits for occupationally exposed individuals. By comparison, the maximum exposed individual for the general population received only 0.062 rem over the entire historical period, which is much less than the exposure to the maximum exposed individual transportation worker and corresponds to 0.0016 mrem exposure per year. It should be noted that the majority of the exposure to the transportation worker and maximum exposed worker is already accounted for since most transportation workers are badged and therefore this exposure is included with all other exposure they would receive on the job. The rail employees and off-site truck drivers are the only transportation workers who are not badged. Their exposure was calculated to be only approximately 30% of the total.

The estimated non-radiological fatalities due to vehicle emissions is 0.028 for the entire 40-year period.

A.8.2 Incident Free

Table A-25 provides a summary of the annual exposures and risks from incident-free transportation of naval spent nuclear fuel and test specimens for all alternatives. The values are calculated by dividing the values in Table A-26 by the 40 years evaluated to obtain the average annual values.

The annual radiological impact on the general population ranges from 0.0085 to 0.30 person-rem. The general population annual radiological risk ranges from 0.0000043 to 0.00015 for cancer fatalities.

The radiological impact on the transportation crew (occupational) ranges from 0.038 to 0.38 person-rem. The transportation crew annual radiological risk ranges from 0.000015 to 0.00015 for cancer fatalities.

Table A-25. Summary of annual incident-free impacts during transportation of naval spent nuclear fuel and test specimens.

	General Population		Occupational		MEI-General Population		MEI-Occupational		Estimated Non-Radiological Facilities (per year)
	Collective Dose (person-rem/yr)	Estimated Cancer Fatalities (per year)	Collective Dose (person-rem/yr)	Estimated Cancer Fatalities (per year)	Dose (rem/yr)	Estimated Cancer Fatalities (per year)	Dose (rem/yr)	Estimated Cancer Fatalities	
No Action	0.0085	4.3 x 10y6	0.038	1.5 x 10y5	0.00098	4.9 x 10y7	0.0087	3.5 x 10y6	1.5 x 10y4
Decentralization - No Exam	0.0085	4.3 x 10y6	0.038	1.5 x 10y5	0.00098	4.9 x 10y7	0.0087	3.5 x 10y6	1.5 x 10y4
Decentralization - Limited Exam	0.021	1.1 x 10y5	0.068	2.7 x 10y5	0.0011	5.5 x 10y7	0.0087	3.5 x 10y6	2.2 x 10y4
Decentralization - Full Exam	0.083	4.2 x 10y5	0.30	1.2 x 10y4	0.0043	2.2 x 10y6	0.032	1.3 x 10y5	7.5 x 10y4
1992-1993 Planning Basis	0.053	2.7 x 10y5	0.18	7.2 x 10y5	0.0022	1.1 x 10y6	0.020	8.0 x 10y6	6.3 x 10y4
Regionalization or Centralization at INEL	0.053	2.7 x 10y5	0.18	7.2 x 10y5	0.0022	1.1 x 10y6	0.020	8.0 x 10y6	6.3 x 10y4
Regionalization or Centralization at Hanford	0.12	6.0 x 10y5	0.25	1.0 x 10y4	0.0040	2.0 x 10y6	0.027	1.1 x 10y5	8.8 x 10y4
Regionalizati	0.30	1.5 x	0.38	1.5 x	0.0040				

on or Centralization at Savannah River		10y4		10y4		2.0 x 10y6	0.12	4.8 x 10y5	8.3 x 10y4
Regionalization or Centralization at Oak Ridge	0.28	1.4 x 10y4	0.35	1.4 x 10y4	0.0040	2.0 x 10y6	0.10	4.0 x 10y5	7.0 x 10y4
Regionalization or Centralization at Nevada Test Site	0.15	7.5 x 10y5	0.28	1.1 x 10y4	0.0040	2.0 x 10y6	0.042	1.7 x 10y5	9.3 x 10y4

Table A-26. Summary of 40-year cumulative incident-free impacts during transportation of naval spent nuclear fuel and test specimens.

	General Population		Occupational		MEI-General Population		MEI-Occupational		Estimated Non-Radiological Fatalities
	Collective Dose (person-rem)	Estimated Cancer Fatalities	Collective Dose (person-rem)	Estimated Cancer Fatalities	Dose (rem)	Estimated Cancer Fatalities	Dose (rem)	Estimated Cancer Fatalities	
No Action	0.34	1.7 x 10y4	1.5	6.0 x 10y4	0.039	2.0 x 10y5	0.35	1.4 x 10y4	5.9 x 10y3
Decentralization - No Exam	0.34	1.7 x 10y4	1.5	6.0 x 10y4	0.039	2.0 x 10y5	0.35	1.4 x 10y4	5.9 x 10y3
Decentralization - Limited Exam	0.83	4.2 x 10y4	2.7	1.1 x 10y3	0.045	2.3 x 10y5	0.35	1.4 x 10y4	8.9 x 10y3
Decentralization - Full Exam	3.3	1.7 x 10y3	12	4.8 x 10y3	0.17	8.5 x 10y5	0.43	1.7 x 10y4	3.0 x 10y2
1992-1993 Planning Basis	2.1	1.1 x 10y3	7.3	2.9 x 10y3	0.086	4.3 x 10y5	0.80	3.2 x 10y4	2.5 x 10y2
Regionalization or Centralization at INEL	2.1	1.1 x 10y3	7.3	2.9 x 10y3	0.086	4.3 x 10y5	0.80	3.2 x 10y4	2.5 x 10y2
Regionalization or Centralization at Hanford	4.7	2.4 x 10y3	9.8	3.9 x 10y3	0.16	8.0 x 10y5	1.1	4.4 x 10y4	3.5 x 10y2

Regionalization or Centralization at Savannah River	12	6.0 x 10y3	15	6.0 x 10y3	0.16	8.0 x 10y5	4.7	1.9 x 10y3	3.3 x 10y2
Regionalization or Centralization at Oak Ridge	11	5.5 x 10y3	14	5.6 x 10y3	0.16	8.0 x 10y5	4.1	1.6 x 10y3	2.8 x 10y2
Regionalization or Centralization at Nevada Test Site	6.0	3.0 x 10y3	11	4.4 x 10y3	0.16	8.0 x 10y5	1.7	6.8 x 10y4	3.7 x 10y2

For all alternatives, the maximum exposed individual is a transportation worker who drives the truck shipments. The annual radiological impact on the maximum exposed individual ranges from 0.0087 to 0.12 rem. These values were calculated based on the modeling approach that for each of the categories of shipments described in Sections A.4.2 through A.4.4, the same person would drive all shipments. The maximum exposed individual annual radiological risk ranges from 0.0000035 to 0.000048 for cancer fatalities. The annual exposure to the maximum exposed individual of the general population ranges from 0.00098 to 0.0043 rem for the various alternatives. The estimated exposure and health effects to the maximum exposed individual for the general population correspond to approximately a factor of 10 less than those estimated for the transportation worker.

The annual non-radiological risk ranges from 0.00015 to 0.00093 fatalities.

The summary of exposures and risks from incident-free transportation of naval spent nuclear fuel and test specimens for all alternatives are included in Table A-26 for the 40-year period.

The radiological impact on the general population ranges from 0.34 to 12 person-rem. The general population radiological risk for the entire 40-year period ranges from 0.00017 to 0.006 for cancer fatalities.

The radiological impact on the transportation crew (occupational) ranges from 1.5 to 15 person-rem. The transportation crew radiological risk for the entire 40-year period ranges from 0.0006 to 0.006 for cancer fatalities.

For all alternatives, the maximum exposed individual is a transportation worker who drives the truck shipments. The radiological impact on the maximum exposed individual ranges from 0.35 to 4.7 rem. These values were calculated based on using the same driver for all shipments for each of the categories of shipments described in Sections A.4.2 through A.4.4. The maximum exposed individual radiological risk for the entire 40-year period, 1995 through 2035, ranges from 0.00014 to 0.0019 for cancer fatalities. The exposure to the maximum exposed individual of the general population ranges from 0.039 to 0.17 rem for the various alternatives. The estimated exposure and health effects to the maximum exposed individual for the general population correspond to approximately a factor of 10 less than those estimated for the transportation worker.

The non-radiological risk ranges from 0.0059 to 0.037 fatalities for the entire 40-year period.

There are appreciable differences in exposure to the general population, transportation crew, and the maximum exposed individual among the various alternatives. Part of these differences is due to the varying number of shipments. For example, for the Decentralization - Full Examination alternative, all shipments of naval spent nuclear fuel are shipped to the INEL and then returned to the shipyards and prototypes, thereby doubling the number of shipments. However, the single most important contributor to the differences among the alternatives is the shipment of test specimen assemblies. For the No

Action, Decentralization - No Examination, and Decentralization - Limited Examination alternatives, there are no shipments; for the Decentralization - Full Examination, 1992/1993 Planning Basis, Regionalization at INEL, and Centralization at INEL alternatives, the exposure is minimal since the shipments remain on the INEL site. However, for the other Regionalization and Centralization alternatives, the test specimen assemblies would be shipped off-site between the INEL and the alternative sites. While the exposure rates on the casks are low, the number of shipments and the distances involved increase the radiological impact on the transportation crew and the general population.

Tables A-27 and A-28 provide the 40-year cumulative incident-free results separately for on-site and off-site shipments. For all alternatives, the shipments of naval spent nuclear fuel from shipyards and prototypes and shipments of naval irradiated test specimens are off-site. Likewise, the transfers of naval spent nuclear fuel to storage following examination are on-site for all alternatives. The transfers of naval test specimen assemblies are off-site for the Regionalization and Centralization alternatives at Hanford, Savannah River, Oak Ridge, and the Nevada Test Site, otherwise they would be on-site.

As described in Section 3.8 of the main body of this Appendix, all alternatives which do not make use of the existing Expended Core Facility at INEL would require a transition period while new facilities for examination and storage of naval spent nuclear fuel were developed. During the transition period, approximately 80 shipments from Navy sites to ECF would be needed. These shipments are not included explicitly in the detailed analyses; however, the appropriate number of shipments needed by each alternative during this period is explicitly included, so the range of environmental effects of these shipments is bounded. For example, the estimated fatalities for the No Action, Decentralization - No Examination, and Decentralization - Limited Examination alternatives would actually increase slightly if the transition shipments were included. The estimated fatalities for the alternatives in which the INEL continues to receive shipments would remain the same. For the Regionalization and Centralization alternatives at sites other than INEL, the estimated fatalities would

Table A-27. Summary of 40-year cumulative incident-free impacts of on-site transportation.

	General Population		Occupational		MEI-General Population		MEI-Occupational		Estimated Non-Radiological Fatalities
	Collective Dose (person-rem)	Estimated Cancer Fatalities	Collective Dose (person-rem)	Estimated Cancer Fatalities	Dose (rem)	Estimated Cancer Fatalities	Dose (rem)	Estimated Cancer Fatalities	
No Action	0.00010	5.0 x 10y8	0.0018	7.2 x 10y7	0.000017	8.5 x 10y9	0.0017	6.8 x 10y7	0
Decentralization - No Exam	0.00010	5.0 x 10y8	0.0018	7.2 x 10y7	0.000017	8.5 x 10y9	0.0017	6.8 x 10y7	0
Decentralization - Limited Exam	0.00010	5.0 x 10y8	0.0018	7.2 x 10y7	0.000017	8.5 x 10y9	0.0017	6.8 x 10y7	0
Decentralization - Full	0.013	6.5 x 10y6	0.44	1.8 x 10y4	0.062	3.1 x 10y5	0.43	1.7 x	0

Exam								10y4	
1992-1993 Planning Basis	0.015	7.5 x 10y6	0.50	2.0 x 10y4	0.062	3.1 x 10y5	0.43	1.7 x 10y4	0
Regionalization or Centralization at INEL	0.015	7.5 x 10y6	0.50	2.0 x 10y4	0.062	3.1 x 10y5	0.43	1.7 x 10y4	0
Regionalization or Centralization at Hanford	0.0024	1.2 x 10y6	0.067	2.7 x 10y5	0.000017	8.5 x 10y9	0.065	2.6 x 10y5	0
Regionalization or Centralization at Savannah River	0.0024	1.2 x 10y6	0.067	2.7 x 10y5	0.000017	8.5 x 10y9	0.065	2.6 x 10y5	0
Regionalization or Centralization at Oak Ridge	0.0024	1.2 x 10y6	0.067	2.7 x 10y5	0.000017	8.5 x 10y9	0.065	2.6 x 10y5	0
Regionalization or Centralization at Nevada Test Site	0.0024	1.2 x 10y6	0.067	2.7 x 10y5	0.000017	8.5 x 10y9	0.065	2.6 x 10y5	0

Table A-28. Summary of 40-year cumulative incident-free impacts of off-site transportation.

	General Population		Occupational		MEI-General Population		MEI-Occupational		Estimated Non-Radiological Fatalities
	Collective Dose (person-rem)	Estimated Cancer Fatalities	Collective Dose (person-rem)	Estimated Cancer Fatalities	Dose (rem)	Estimated Cancer Fatalities	Dose (rem)	Estimated Cancer Fatalities	
No Action	0.34	1.7 x 10y4	1.5	6.0 x 10y4	0.039	2.0 x 10y5	0.35	1.4 x 10y4	5.9 x 10y3
Decentralization - No Exam	0.34	1.7 x 10y4	1.5	6.0 x 10y4	0.039	2.0 x 10y5	0.35	1.4 x 10y4	5.9 x 10y3
Decentralization - Limited Exam	0.83	4.2 x 10y4	2.7	1.1 x 10y3	0.045	2.3 x 10y5	0.35	1.4 x 10y4	8.9 x 10y3
Decentralization - Full Exam	3.3	1.7 x 10y3	11	4.4 x 10y3	0.17	8.5 x 10y5	0.35	1.4 x 10y4	3.0 x 10y2
1992-1993	2.1	1.1 x	6.8	2.7 x	0.086	4.3 x	0.80	3.2 x	2.5 x

Planning Basis		10y3		10y3		10y5		10y4	10y2
Regionalization or Centralization at INEL	2.1	1.1 x 10y3	6.8	2.7 x 10y3	0.086	4.3 x 10y5	0.80	3.2 x 10y4	2.5 x 10y2
Regionalization or Centralization at Hanford	4.7	2.4 x 10y3	9.7	3.9 x 10y3	0.16	8.0 x 10y5	1.1	4.4 x 10y4	3.5 x 10y2
Regionalization or Centralization at Savannah River	12	6.0 x 10y3	15	6.0 x 10y3	0.16	8.0 x 10y5	4.7	1.9 x 10y3	3.3 x 10y2
Regionalization or Centralization at Oak Ridge	11	5.5 x 10y3	14	5.6 x 10y3	0.16	8.0 x 10y5	4.1	1.6 x 10y3	2.8 x 10y2
Regionalization or Centralization at Nevada Test Site	6.0	3.0 x 10y3	11	4.4 x 10y3	0.16	8.0 x 10y5	1.7	6.8 x 10y4	3.7 x 10y2

also remain approximately the same since the number of shipments is approximately evenly distributed between the east and west coast origins and therefore the total distance traveled is the same.

A.8.3 Accident Risk

This section summarizes the results of the calculations for radiological and non-radiological risks from accidents which could occur during shipments of naval spent nuclear fuel and test specimens. Tables A-29 and A-30 provide the results of the accident risk assessment for each alternative. The risks are provided for the general population in terms of exposure and estimated cancer fatalities. The risks are presented for 50% meteorological conditions, Pasquill Stability Class D. Table A-29 provides the risks on an annual basis and Table A-30 provides the total risks over the entire 40-year period.

The annual radiological impact, from Table A-29, on the general population ranges from 0.00021 to 0.021 person-rem. These exposures equate to 0.00000011 to 0.000011 estimated cancer fatalities. For non-radiological impacts, the estimated annual fatalities from traffic accidents range from 0.0012 to 0.022.

The cumulative radiological impact, from Table A-30, on the general population ranges from 0.0082 to 0.84 person-rem. These exposures equate to 0.0000041 to 0.00042 estimated cancer fatalities. For non-radiological impacts, the estimated fatalities from traffic accidents range from 0.047 to 0.84.

There are appreciable differences in exposure to the general population, transportation crew, and the maximum exposed individual among the various alternatives. Part of these differences is due to the varying number of shipments. For example, for the Decentralization - Full Examination alternative, all shipments of naval spent nuclear fuel are shipped to the INEL and then returned to the shipyards and prototypes, thereby doubling the number of shipments. As in the incident-free assessment, the shipment of test specimen assemblies is a large factor. For the No Action, Decentralization - No Examination, and Decentralization - Limited Examination alternatives, there are no shipments; for the Decentralization - Full Examination, 1992/1993 Planning Basis, Regionalization at INEL, and Centralization at INEL alternatives, the exposure is minimal since the shipments remain on the INEL site. However, for the other Regionalization and Centralization alternatives, the test specimen assemblies would be shipped off-site between the INEL and the alternate sites. While the exposure rates on the containers are low, the number of shipments and the distances involved increase the radiological impact on the transportation crew and the general population. In addition, the routes themselves are an important factor. While differences in distance and population densities are important, the higher risk for the Regionalization at Savannah River and Centralization at Savannah River alternatives, in particular, is due to the higher accident rates along the route taken and higher food transfer factors for shipments through farming states with much higher ingestion rates.

Table A-29. Summary of annual accident risk for transportation of naval spent nuclear fuel and test specimens.

	General Population Collective Dose (person-rem/yr)	Estimated Cancer Fatalities (per year)	Estimated Traffic Fatalities (per year)
	Class D	Class D	
No Action	0.00021	1.1 x 10y7	1.2 x 10y3
Decentralization - No Exam	0.00021	1.1 x 10y7	1.2 x 10y3
Decentralization - Limit Exam	0.00043	2.2 x 10y7	1.6 x 10y3
Decentralization - Full	0.0028	1.4 x 10y6	2.2 x 10y2
1992/1993 Planning Basis	0.0020	1.0 x 10y6	1.3 x 10y2
Regionalization or Centralization at INEL	0.0020	1.0 x 10y6	1.3 x 10y2
Regionalization or Centralization at Hanford	0.0033	1.7 x 10y6	1.3 x 10y2
Regionalization or Centralization at Savannah River	0.0210	1.1 x 10y5	1.5 x 10y2
Regionalization or Centralization at Oak Ridge	0.015	7.5 x 10y6	1.4 x 10y2
Regionalization or Centralization at Nevada Test Site	0.0070	3.5 x 10y6	1.5 x 10y2

Table A-30. Summary of cumulative accident risk over the 40-year period for transportation of naval spent nuclear fuel and test specimens.

	General Populatio Collective Dose (person-rem)	Estimated Cancer Fatalities	Estimated Traffic Fatalities
	Class D	Class D	
No Action	0.0082	4.1 x 10y6	4.7 x 10y2
Decentralization - No Exam	0.0082	4.1 x 10y6	4.7 x 10y2
Decentralization - Limited Exam	0.017	8.5 x 10y6	6.5 x 10y2
Decentralization - Full Exam	0.11m	5.5 x 10y5	8.6 x 10y1
1992/1993 Planning Basis	0.079	4.0 x 10y5	5.1 x 10y1
Regionalization or Centralization at INEL	0.079	4.0 x 10y5	5.1 x 10y1
Regionalization or Centralization at Hanford	0.13	6.5 x 10y5	5.3 x 10y1
Regionalization or Centralization at Savannah River	0.84	4.2 x 10y4	6.0 x 10y1
Regionalization or Centralization at Oak Ridge	0.61	3.1 x 10y4	5.7 x 10y1
Regionalization or Centralization at Nevada Test Site	0.28	1.4 x 10y4	6.1 x 10y1

Table A-31 provides the 40-year cumulative risk, separated by on-site and off-site shipments.

As described in Section 3.8 of the main body of this Appendix, a transition period could be necessary which would require approximately 80 shipments from Navy sites to ECF. These shipments are not included explicitly in the detailed analyses; however, the appropriate number of shipments engendered by each alternative during this period is explicitly included, so the range of environmental effects of these shipments is bounded. The addition of the transition shipments would increase the distance traveled for the No Action, Decentralization - No Examination, and Decentralization - Limited Examination alternatives. Since the accident risk is proportional to the distance traveled, the risk would increase slightly for these alternatives, which were the lowest of all alternatives. All other alternatives would remain the same. Therefore, incorporating the transition period would actually reduce the difference between alternatives from the standpoint of transportation effects.

A.8.4 Accident Maximum Consequences

This section summarizes the results of the calculations of maximum consequences of accidents which could occur during shipments of naval spent nuclear fuel and test specimens. Tables A-32 and A-33 provide the results of the maximum consequence assessment for each alternative. The maximum consequences are provided for the general population by population area (rural, suburban, and urban) and the maximum exposed individual in terms of exposure. The members of the transportation crew may be the maximum exposed individual.

Table A-31. Summary of cumulative risk over the 40-year period for transportation of naval spent nuclear fuel and test specimens (on-site/off-site).

	ON-SITE General Population			OFF-SITE General Population		
	Collective Dose (person-rem)	Estimated Cancer Fatalities	Estimated Traffic Fatalities	Collective Dose (person-rem)	Estimated Cancer Fatalities	Estimated Traffic Fatalities
No Action	1.3 x 10y6	6.5 x 10y10	6.8 x 10y6	0.0082	4.1 x 10y6	4.7 x 10y2
Decentralization - No Exam	1.3 x 10y6	6.5 x 10y10	6.8 x 10y6	0.0082	4.1 x 10y6	4.7 x 10y2
Decentralization - Limited Exam	1.3 x 10y6	6.5 x 10y10	6.8 x 10y6	0.017	8.5 x 10y6	6.3 x 10y2
Decentralization - Full Exam	4.1 x 10y5	2.1 x 10y8	3.2 x 10y4	0.11	5.5 x 10y5	8.4 x 10y1
1992-1993 Planning Basis	1.3 x 10y4	6.5 x 10y8	6.1 x 10y4	0.079	4.0 x 10y5	5.0 x 10y1
Regionalization or Centralization at INEL	1.3 x 10y4	6.5 x 10y8	6.1 x 10y4	0.079	4.0 x 10y5	5.0 x 10y1
Regionalization or Centralization at Hanford	8.7 x 10y5	4.4 x 10y8	2.1 x 10y4	0.13	6.5 x 10y5	5.3 x 10y1
Regionalization or Centralization at Savannah River	8.7 x 10y5	4.4 x 10y8	3.6 x 10y4	0.84	4.2 x 10y4	5.9 x 10y1
Regionalization or Centralization at Oak Ridge	8.7 x 10y5	4.4 x 10y8	2.3 x 10y4	0.61	3.1 x 10y4	5.7 x 10y1
Regionalization or Centralization at Nevada Test Site	8.7 x 10y5	4.4 x 10y8	1.6 x 10y4	0.28	1.4 x 10y4	6.0 x 10y1

Table A-32. Summary of maximum consequences (person-rem) of an accident (Design Basis).

MAXIMUM CONSEQUENCES
DESIGN BASIS
(accident probability between 1 and 1 x 10y6)

	Maximum Exposed Individual (rem)	Rural (person-rem)	Suburban (person-rem)	Urban (person-rem)
No Action	0.0034	0.51	4.3	13
Decentralization - No Exam	0.0034	0.51	4.3	13
Decentralization - Limited Exam	0.014	4.0	4.3	13
Decentralization - Full Exam	0.045	7.4	25	13
1992/1993 Planning Basis	0.045	7.4	25	13
Regionalization or Centralization at INEL	0.045	7.4	25	13
Regionalization or Centralization at Hanford	0.25	38	100	56
Regionalization or Centralization at Savannah River	0.25	38	320	560
Regionalization or Centralization at Oak Ridge	0.25	38	320	560
Regionalization or Centralization at Nevada Test Site	0.25	38	320	560

Table A-33. Summary of maximum consequences (person-rem) of an accident (Beyond Design Basis).

MAXIMUM CONSEQUENCES
BEYOND DESIGN BASIS
(accident probability between 1 x 10y6 and 1 x 10y7)

	Maximum Exposed Individual		Rural		Suburban		Urban	
	Estimated Dose (rem)	Estimated Cancer Fatalities	Estimated Collective Dose (person-rem)	Estimated Cancer Fatalities	Estimated Collective Dose (person-rem)	Estimated Fatal Cancers	Estimated Collective Dose	Estimated Cancer Fatalities
No Action	0.014	7.0 x 10y6	4.0	2.0 x 10y3	25	1.3 x 10y2	23	1.2 x 10y2
Decentralization No Exam	0.014	7.0 x 10y6	4.0	2.0 x 10y3	25	1.3 x 10y2	23	1.2 x 10y2
Decentralization Limited Exam	0.045	2.3 x 10y5	7.4	3.7 x 10y3	25	1.3 x 10y2	130	6.5 x 10y2
Decentralization Full Exam	1.8	9.0 x 10y4	2700	1.4	3300	1.7	130	6.5 x 10y2
1992/1993 Planning Basis	2.2	1.1 x 10y3	3300	1.7	4100	2.1	130	6.5 x 10y2
Regionalization or Centralization at INEL	2.2	1.1 x 10y3	3300	1.7	4100	2.1	130	6.5 x 10y2
Regionalization or Centralization at Hanford	2.2	1.1 x 10y3	3300	1.7	4100	2.1	560	2.8 x 10y1
Regionalization or Centralization at Savannah River	2.2	1.1 x 10y3	3300	1.7	4100	2.1	1700	8.5 x 10y1
Regionalization or Centralization at Oak Ridge	2.2	1.1 x 10y3	3300	1.7	4100	2.1	1700	8.5 x 10y1
Regionalization or Centralization at Nevada Test Site	2.2	1.1 x 10y3	3300	1.7	4100	2.1	1700	8.5 x 10y1

For design basis accidents, the calculated exposure to the general population ranges from 0.51 person-rem in a rural area to 560 person-rem in an urban area. The risk associated with these exposures ranges from 0.00026 to 0.28 cancer fatalities. The exposure to the maximum exposed individual ranges from 0.0034 rem to 0.25 rem. The risk to the maximum individual ranges from 0.0000017 to 0.00013 cancer fatalities.

For beyond design basis accidents, the exposure to the general population ranges from 4.0

person-rem in a rural area to 4100 person-rem in a suburban area (in this case, the probability of the accident of the same consequence in the urban area was less than 1 x 10y7). The risk associated with these exposures ranges from 0.002 to 2.1 cancer fatalities. The exposure to the maximum exposed individual ranges from 0.014 rem to 2.2 rem. The risk to the maximum individual ranges from 0.000007 to 0.0011 cancer fatalities.

The shipments of naval spent nuclear fuel from shipyards and prototypes, transfers of naval spent nuclear fuel to storage, transfers of test specimen assemblies to the examination facility, and shipments of test specimens to test facilities were evaluated for the maximum consequences of an accident. Although the naval spent nuclear fuel shipments contain a higher amount of activity per shipment, there are cases where the test specimen shipment consequences are larger. The consequences are larger primarily due to the higher number of shipments which increases the probabilities such that a more severe consequence is evaluated.

Tables A-34 and A-35 provide the maximum consequences, separated by on-site and off-site shipments, respectively.

As described in Section 3.8 of the main body of this Appendix, a transition period could be necessary which would require approximately 80 shipments from Navy sites to ECF. These shipments are not included explicitly in the detailed analyses; however, the appropriate number of shipments engendered by each alternative during this period is explicitly included, so the range of environmental effects of these shipments is bounded. Since all alternatives ship the same basic fuel types, the maximum consequences are determined by the probability of the accident which is a function of the distance traveled. As described in Section A.8.3, only the No Action, Decentralization - No Examination, and Decentralization - Limited Examination alternatives, which have the lowest estimated maximum consequences, would increase the distance traveled if the

Table A-34. Summary of maximum consequences of an on-site accident (Beyond Design Basis).

	MEI		Rural		Suburban		Urban	
	Collective Dose (person-rem)	Estimated Cancer Fatalities	Collective Dose (person-rem)	Estimated Cancer Fatalities	Collective Dose (person-rem)	Estimated Cancer Fatalities	Collective Dose (person-rem)	Estimated Cancer Fatalities
No Action	0.0013	6.5 x 10y7	0.37	1.9 x 10y4	2.4	1.2 x 10y3	N/A	N/A
Decentralization - No Exam	0.0013	6.5 x 10y7	0.37	1.9 x 10y4	2.4	1.2 x 10y3	N/A	N/A
Decentralization - Limited Exam	0.0013	6.5 x 10y7	0.37	1.9 x 10y4	2.4	1.2 x 10y3	N/A	N/A
Decentralization - Full Exam	0.51	2.6 x 10y4	200	1.0 x 10y1	100	5.0 x 10y2	N/A	N/A
1992-1993 Planning Basis	2.2	1.1 x 10y3	3300	1.7	4100	2.1	N/A	N/A
Regionalization or Centralization at INEL	2.2	1.1 x 10y3	3300	1.7	4100	2.1	N/A	N/A
Regionalization or Centralization at Hanford	2.2	1.1 x 10y3	3300	1.7	4100	2.1	N/A	N/A

Regionalization or Centralization at Savannah River	2.2	1.1 x 10y3	3300	1.7	4100	2.1	N/A	N/A
Regionalization or Centralization at Oak Ridge	2.2	1.1 x 10y3	3300	1.7	4100	2.1	N/A	N/A
Regionalization or Centralization at Nevada Test Site	2.2	1.1 x 10y3	3300	1.7	4100	2.1	N/A	N/A

Table A-35. Summary of maximum consequences of an off-site accident

	MEI		Rural		Suburban		Urban	
	Collective Dose (person-rem)	Estimated Cancer Fatalities	Collective Dose (person-rem)	Estimated Cancer Fatalities	Collective Dose (person-rem)	Estimated Cancer Fatalities	Collective Dose (person-rem)	Estimated Cancer Fatalities
No Action	0.014	7.0 x 10y6	4.0	2.0 x 10y3	25	1.3 x 10y2	23	1.2 x 10y2
Decentralization - No Exam	0.014	7.0 x 10y6	4.0	2.0 x 10y3	25	1.3 x 10y2	23	1.2 x 10y2
Decentralization - Limited Exam	0.045	2.3 x 10y5	7.4	3.7 x 10y3	25	1.3 x 10y2	130	6.5 x 10y2
Decentralization - Full Exam	1.8	9.0 x 10y4	2700	1.4	3300	1.7	130	6.5 x 10y2
1992-1993 Planning Basis	1.8	9.0 x 10y4	2700	1.4	79	4.0 x 10y2	130	6.5 x 10y2
Regionalization or Centralization at INEL	1.8	9.0 x 10y4	2700	1.4	79	4.0 x 10y2	130	6.5 x 10y2
Regionalization or Centralization at Hanford	1.8	9.0 x 10y4	2700	1.4	320	1.6 x 10y1	560	2.8 x 10y1
Regionalization or Centralization at Savannah River	1.8	9.0 x 10y4	2700	1.4	320	1.6 x 10y1	1700	8.5 x 10y1
Regionalization or Centralization at Oak Ridge	1.8	9.0 x 10y4	2700	1.4	320	1.6 x 10y1	1700	8.5 x 10y1
Regionalization or Centralization at Nevada Test Site	1.8	9.0 x 10y4	2700	1.4	320	1.6 x 10y1	1700	8.5 x 10y1

transition shipments were included. Therefore, incorporating the transition period would actually reduce the difference between alternatives from the standpoint of transportation effects.

A.9 EFFECT ON ENVIRONMENTAL JUSTICE

The only method used to ship naval spent nuclear fuel to INEL in the past and the only method proposed for future shipments is by rail. The only exceptions to this are that naval spent nuclear fuel from Pearl Harbor Naval Shipyard is transported by ship from Hawaii to Puget Sound Naval Shipyard where the shipping containers are transferred to railcars for the journey to INEL, and a heavy-lift transporter is used to move the shipping containers from the Kesselring Site a few miles to the nearest railhead. The mode of shipment used for naval spent nuclear fuel tends to limit the exposure to members of the general public during transportation. The shipments pass through urban, suburban, and rural areas, using routes selected by the railroads in accordance with applicable regulations and the requirements of the load. The fractions of the distance traveled in urban, suburban, and rural areas range from about 2.5% urban, 12.5% suburban, and 85% rural to approximately 4% urban, 35% suburban, and 61% rural, depending on the alternative considered.

As shown in the analyses in this Attachment, the impacts on human health or the environment resulting from routine transport of naval spent nuclear fuel and hypothetical transportation accidents would be small for all of the alternatives considered. For example, it is unlikely that a single additional cancer would occur as a result of the transportation of naval spent nuclear fuel under any alternative. Shipping accidents could occur at any location along the routes used, so it is not possible to identify the minority or low-income composition of the populations along the routes. However, the fact that the potential impacts due to an accident for any of the alternatives considered would present no significant risk and do not constitute a credible adverse impact on the population along the shipping routes makes it possible to state that no adverse effects from accidents associated with the management of naval spent nuclear fuel would be expected for any specific segment of the population, minorities and low-income groups included.

To place the impacts on environmental justice in perspective, the risk from routine shipping activities or hypothetical accidents associated with transportation of naval spent nuclear fuel under any of the alternatives considered would amount to less than one additional fatality per year in the entire population. For comparison, in 1990 there were approximately 40,000 traffic fatalities in the United States population and there were about 7,400 deaths caused by traffic accidents among people of color in the U. S. Even if all of the additional cancer deaths associated with an accident for any of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would experience far less than one additional fatality per year. The same conclusion can be drawn for low-income groups.

A.10 REFERENCES

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ATTACHMENT B - DESCRIPTION OF NAVAL SPENT NUCLEAR FUEL RECEIPT AND

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DESCRIPTION OF NAVAL SPENT NUCLEAR FUEL RECEIPT AND HANDLING AT THE EXPENDED CORE FACILITY AT THE IDAHO NATIONAL ENGINEERING LABORATORY

B.1 GENERAL DESCRIPTION AND OPERATION OF FACILITIES

The Expended Core Facility (ECF) is located within the confines of the Naval Reactors Facility (NRF) at the Idaho National Engineering Laboratory (INEL). It is a large laboratory facility used to receive, examine, prepare for storage, and ship naval spent nuclear fuel and irradiated test specimen assemblies. The information derived from the examinations performed at ECF provides engineering data on nuclear reactor environments, material behavior, and design performance. These data are used to develop new technology and to improve the cost-effectiveness of existing designs.

Naval spent nuclear fuel is prepared at ECF for storage and shipment to the Idaho Chemical Processing Plant (ICPP). Some naval equipment contaminated by radioactive material during use in the fleet is refurbished for reuse.

The building which houses ECF is a concrete block structure approximately 1000 feet by 194 feet. This space provides offices and enclosed work areas, including an array of interconnected reinforced concrete water pools which permit visual observation of naval spent nuclear fuel during handling and inspection while shielding workers from radiation. Adjacent to the water pools are shielded cells used for operations which must be performed dry. Access to ECF for receipt and shipping of large containers is provided by large roll-up doors that allow railcar and truck entry. A schematic view of ECF is shown in Figure B-1 and a photograph of the water pool area is provided in Figure B-2.

ECF has been specifically designed to provide the unique physical and administrative controls required by the Naval Nuclear Propulsion Program to ensure safe handling of irradiated and contaminated nuclear fuels and components with a high degree of worker safety and protection for the environment. The original ECF building was constructed in 1957, and consisted of a water pool and a shielded cell with a connecting transfer canal. The facility has been modified as necessary to accomplish the expanding mission of the facility since then, including the addition of three more water pools, several shielded cells, and other capabilities dictated by the nature of the work required.

Figure B-1. Schematic view of Expanded Core Facility. Figure B-2. Expanded Core Facility water pool area.

B.1.1 Water Pools

The purpose of the four interconnected water pools is to permit viewing and examination of radioactive reactor components and specimens while providing radiation shielding for workers.

Walls and stainless steel gates divide the water pools into smaller work areas called zones. This partitioning makes it possible to drain a small portion of the total water pool volume when facility equipment maintenance or repair is required. It also would permit isolation of an individual zone if a leak were to develop which, combined with transfer of the water from that pool to holding facilities, would minimize the loss of water.

B.1.1.1 Water Pit No. 1. This pool is used for the removal of spent fuel from shipping containers, and for preparation of fuel and low-level waste for shipment to ICPP. It also contains fuel and non-fuel storage areas.

B.1.1.2 Water Pit No. 2. This water pool is used for handling irradiation test assemblies.

Various components are tested for their reaction to radiation. Test assemblies returned from the Advanced Test Reactor (ATR) at INEL are unloaded from the shipping cask and disassembled. Verification of test integrity and connection of electrical and mechanical monitoring devices are performed.

B.1.1.3 Water Pit No. 3. Radioactive components are separated by milling machines into smaller units for examination in this water pool. Dimensional measuring equipment is used to examine selected components. Fuel storage racks are also located in Water Pit No. 3.

Observation rooms are located along the northern wall of this water pool. These rooms are below the level of the water surface and have viewing windows into the water pool. Components may be visually examined and remotely handled underwater for shielding purposes from these rooms.

B.1.1.4 Water Pit No. 4. Operations performed in this water pool include spent fuel removal from transfer containers, temporary fuel storage in racks, fuel examination, and preparations for spent fuel shipments. Observation rooms are located along the northern wall of the water pool. This water pool also contains the transfer canals that would link the water pools with the proposed Dry Cell Project, which would prepare spent fuel for shipment in a dry, enclosed environment.

B.1.1.5 Construction. All of the water pools are constructed of reinforced concrete in such a

manner that they are watertight. The water pool floors are designed to support installed equipment and shielded shipping containers weighing up to 100 tons with a minimum base area of 8 square feet. Water pool zone depths range from 20 feet to 45 feet. Water pool walls and floors are coated with a thermo-setting plastic coating which is highly resistant to radiation damage, is easy to decontaminate, and serves as an extra barrier to water leakage.

B.1.1.6 Water Treatment and Minimizing Radioactive Contamination. Radioactive contaminants which

have accumulated in the ECF water pools through the introduction of corrosion products from irradiation test assemblies and the unloading of spent fuel are removed by various filtration techniques. The design basis for the ECF water treatment system is to allow no discharge of radioactive material to the environment, maintain water clarity, and minimize the amount of radioactive contaminants in the water.

The design goals are accomplished through the use of water purification modules, water pool surface skimming to remove film and floating material, and water recycling systems. The water purification modules prefilter the water to remove particles larger than 60 microns in diameter, remove any dissolved solids in ion-exchange resin beds, and remove any organic or suspended material by absorption in an activated carbon bed. Spent resin, carbon, and filter elements are disposed of as solid radioactive waste.

B.1.1.7 Water Management. The total volume of the ECF water pools (excluding the two new

transfer canals that are empty) is 3,000,000 gallons. A 1-inch difference in the water pool level is equivalent to approximately 9,300 gallons.

The water pools are maintained at a nearly constant level. Alarms are installed to indicate both high and low level conditions. The total water volume is accounted for monthly. Any addition of water to the system is reported to a separate NRF site organization for an independent verification of water volume.

Water leaves the water pools via evaporation, temporary filling of shipping containers, decontamination of equipment, and transfers to retention basins. The water pool evaporation rate has been calculated theoretically and confirmed by experiment. Water returns to the water pools by transfers from the retention basins and by draining shipping containers. Water removed from the system due to evaporation and equipment decontamination is replaced by adding demineralized water.

ECF has the capability of storing 235,000 gallons of water pool water in three underground, steel-reinforced, concrete storage basins. Two of the vaults each have a 40,000-gallon capacity, and the third has a 155,000-gallon capacity. These basins provide the capability to replenish the water pools and receive water pool water if draining a water pool zone is necessary.

B.1.2 Shielded Cells

There are 14 concrete shielded cells in the facility. These shielded cells are used for examination of smaller components, such as specimens which have been removed from irradiation tests that have been exposed to a neutron flux in the ATR, and fuel and non-fuel components from the water pools.

The shielded cells are constructed of concrete, with walls 3 feet thick to provide shielding from radiation. Ventilation in the cell bank maintains negative pressure inside the cells in relation to the rest of the facility. This ensures that radiological contamination is contained within the cells.

All work in the shielded cells is performed remotely by equipment controlled from the cell gallery, and is viewed through shielded lead glass windows. The windows are 3 feet thick, and provide the same shielding value as the concrete walls. The interior of the cells can also be viewed through wall periscopes that permit undistorted viewing of equipment and components.

B.2 RECEIPT AND HANDLING OF NAVAL SPENT NUCLEAR FUEL

B.2.1 Receipt of Spent Fuel

Nuclear-powered ship assignments for refueling, defueling, and overhaul are currently performed by the six nuclear-capable public shipyards (Mare Island, Puget Sound, Pearl Harbor, Portsmouth, Norfolk, and Charleston) and one nuclear-capable private shipyard (Newport News). In 1993, the federal base closing commission included Mare Island and Charleston Naval Shipyards among the bases to be closed in the near future. The spent fuel is removed from nuclear-powered ships and loaded into shipping containers designed specifically for naval spent nuclear fuel. The spent fuel containers are loaded and sealed at the shipyard and shipped to ECF via railcars, as described in Attachment A. A maximum of 48 containers can be staged on the rail siding at NRF outside ECF while awaiting transfer of the spent fuel to the water pools. ECF also receives spent fuel from naval prototype plants in a similar manner.

B.2.2 Handling of Spent Fuel

The shipping containers are brought into the ECF building at one of the two defueling stations and are prepared for defueling by removing the dust cover, leveling, and filling with water. Appropriate containments to prevent release of radioactive material are installed and the container access plug is removed to allow access to the fuel modules.

The containers are unloaded at either the west end defueling station or the east end defueling station. Regardless of the defueling station used, the fuel modules are removed from their shipping container one at a time using a fuel handling machine which draws the module out of the container into a shielded volume, and the entire machine is transferred to the water pools. The fuel module is then discharged into a receiving receptacle in the water pools. Photographs of the two fuel handling machines used are provided in Figures B-3 and B-4.

Every item containing nuclear fuel received at ECF has a unique serial number. When the fuel is removed from its shipping container, two ECF fuel handlers independently read the serial number and compare it to the shipping paperwork. After the serial number is confirmed, the fuel is moved to a uniquely numbered storage port location. Two fuel handlers then independently verify that the fuel is stored in the correct storage location. ECF has a computer-based fuel accountability system which maintains a record of the location and type of every piece of nuclear fuel and how many grams of uranium are contained within the fuel. This system tracks every fuel movement during the time that the fuel is at ECF.

Figure B-3. M-140 container fuel handling machine.

Figure B-4. M-130 container fuel handling machine.

All naval fuel modules have metal structures which contain no fuel above and below the fuel region to facilitate coolant flow and maintain proper support and spacing within the reactor. These upper and lower non-fuel bearing structures must be removed to provide access to the fuel-bearing sections to permit inspection of the module. Removal also reduces the storage space ultimately required for the fuel by approximately 50 percent. The upper and lower non-fuel bearing structures removed during the preparation of fuel modules are evaluated using the waste classification criteria established by federal regulations in 10CFR61 and DOE Order 5820.2. These non-fuel bearing structures do not contain any fuel, or fission products from fuel, and therefore cannot be considered "spent nuclear fuel." They also do not contain transuranic elements or fission products and thus cannot be considered high-level waste or transuranic waste. Therefore, the amounts of radioactivity in the end boxes cause them to be classified as low-level waste. As indicated in Section 5.2.15, the amount of low-level waste generated each year at the Expended Core Facility is 425 cubic meters. The radioactive isotopes which represent 99 percent of the activity in this material are identified as follows:

ISOTOPE	HALF-LIFE (Years)	PRIMARY MODE OF DECAY
Fe-55	2.73	Electron Capture (x-ray)
Co-60	5.271	Beta and Gamma
Ni-59	76,000	Electron Capture
Ni-63	100	Beta

U.S. Nuclear Regulatory Commission 10CFR61 identifies three classes of low-level wastes which are generally suitable for near-surface disposal, namely, Classes A, B, and C. Those meeting the requirements for near-surface disposal are shipped to the INEL Radioactive Waste Management Complex using a shielded cask. Wastes with concentrations greater than those specified for Class C for certain short- and long-lived isotopes were found to be not generally suitable for near-surface disposal. These wastes are classified as Greater Than Class C Low-Level Radioactive Waste. In May 1989, the Nuclear Regulatory Commission promulgated a rule that requires disposal of commercially generated low-level waste with concentrations of radioactivity greater than Class C in a deep geologic repository, unless disposal elsewhere is approved by the Nuclear Regulatory Commission.

Currently, a small amount (about 25 cubic meters) of greater than Class C low-level waste in material removed from the ends of naval spent nuclear fuel modules over the years is being stored at the Naval Reactors Facility pending availability of a disposal facility licensed by the Nuclear Regulatory Commission. This material has been collected and held at the Expended Core Facility for many years. This practice is expected to continue over the period of time covered by this Environmental Impact Statement.

After these upper and lower metal structures have been removed from a fuel module, a lifting fixture is installed to facilitate handling. Prepared fuel may then be inspected immediately or it may be held for a time prior to inspection in storage racks in the water pool. In the event that the fuel is temporarily stored while awaiting inspection, spacers are placed at the bottom of the selected port in the storage rack to maintain the position of the fuel module close to the top of the rack to make movement of the module easier.

Visual examinations of all modules are performed to verify that the fuel has performed as expected. As discussed in Section 2.4.1, about 10 to 20 percent of the spent reactor cores are selected for more detailed examination or destructive analysis in accordance with the needs of the Naval Reactors fuel development program. The more extensive examinations performed in the water pools include measurements of key dimensions of the modules and collection of specimens to be examined in the shielded cells. The specialized equipment used to perform examinations of naval spent nuclear fuel are described in more detail in the section of this attachment devoted to equipment.

Destructive analyses are performed at the Expended Core Facility or at other laboratories, but all material subjected to such analysis must be removed from the spent fuel modules at the Expended Core Facility.

The last steps of spent fuel handling performed at ECF are staging the module for shipment and loading the module into the shipping cask used to transport spent fuel from ECF to ICPP. The spent fuel may be temporarily stored in the racks in the ECF water pools until a cask becomes available to transfer the material to ICPP.

B.2.3 Shipment of Fuel to the Idaho Chemical Processing Plant

A lead-filled, stainless steel shipping cask is used to transport naval and prototype spent fuel modules from ECF to ICPP. The cask is removed from its transport truck and lowered into the ECF water pool until it rests on the floor of the pool. The closure head is removed, and inserts are placed in the cask to provide proper spacing of fuel and to maintain proper positioning during transport of the modules. The modules are inserted into the cask, the closure head is reinstalled, and the cask is lifted from the water. The cask is drained, the exterior is decontaminated, and the cask is loaded onto the truck for shipment. The transport of the cask to ICPP is described in Attachment A.

B.2.4 Library of Naval Reactor Components

As the first modules of a given fuel design are received at the Expended Core Facility for examination, selected key operating components are retained in "library" storage in the water pools to provide a source of reference. These older components are kept to ensure that there will be a representative item available to assist in diagnosis of problems which may occur in any operating power plant in the fleet. The items chosen for this library are usually those that have been in service the longest so that they display the most pronounced effects of use. As the various fuel design types are replaced in fleet service by newer designs, fuel components related to the fuel design being retired are removed from library storage and shipped to ICPP.

B.3 HANDLING OF IRRADIATED TEST SPECIMENS

The irradiated materials program evaluates small specimens of materials for use in naval reactor systems. The specimens are loaded in sample holders, and the holders are placed in test assemblies at ECF. The assemblies are irradiated at ATR, and returned to ECF for disassembly. The specimens are cleaned, examined, reloaded in a test assembly, and returned to the ATR for continued irradiation. A typical specimen undergoes several cycles of irradiation and examination over several months or years. Examinations include nondestructive and destructive tests. Destructive tests have historically included sectioning of specimens for mechanical testing and metallography. Metallographic work was performed in the ECF hot cells in the past and is planned to be performed on specimens in the future.

After completion of the final examination, specimens are shipped to ICPP for storage or to the INEL Radioactive Waste Management Complex for disposal. Other specimens are shipped to either the Bettis Atomic Power Laboratory near Pittsburgh, Pennsylvania, or the Knolls Atomic Power Laboratory near Schenectady, New York for more detailed examinations.

B.4 DESCRIPTION OF MAJOR ITEMS OF EQUIPMENT

The normal method for moving the fuel in the water pools to designated examination equipment areas is by use of one of five bridge cranes which move on rails located on the tops of the walls of the water pools. The fuel is handled remotely. All fuel movements are controlled by trained personnel, and accountability is maintained both by computer and by personnel using fuel transfer forms.

B.4.1 Water Pool Equipment

ECF has unique equipment in the water pools that has been designed for remote operation underwater to perform specific examinations on naval spent nuclear fuel and irradiated test specimens. Special consideration was given during equipment design to provide for remote repair and replacement of components. A description of the water pool spent nuclear fuel and irradiation test examination equipment is presented below.

B.4.1.1 Water Pool Band Saws. There are two underwater band saws in the ECF water pools.

These band saws are used to remove the non-fuel bearing structural material from the top and bottom of fuel cells in preparation for inspection. The fuel region of the fuel cell remains intact during the cutting procedure.

B.4.1.2 Water Pool Milling Machines. Three milling machines in the water pools are used to

separate spent nuclear fuel components into smaller sections for examination in the shielded cells. The fuel region of the fuel cell remains intact during the machining. The mills are used to section spent fuel into pieces which can be handled in the shielded cells for examinations, such as gamma radiation measurement, or for obtaining smaller specimens for metallurgical analysis or fuel depletion measurement. The mill head of the largest milling machine can be remotely interchanged with a band saw attachment to convert the machine into a cutoff saw.

B.4.1.3 Universal Inspection Station. This equipment is used to obtain dimensional measure-

ments using specially designed probes that are inserted in the fuel module. This equipment can position and rotate the probe in any orientation by a dedicated computer. This information is used to assess dimensional changes in the fuel module.

B.4.1.4 Vertical Inspection Gage. The vertical inspection gage is used for obtaining dimensional

measurements or to trace the contour of the external surfaces of fuel cell assemblies or control rods. This information can be used to provide a three-dimensional image of the fuel cell or control rod at the end of fuel life to determine the effects of fuel element changes on the overall fuel cell assembly dimensions over fuel life and the effects of radiation on control rod dimensions over fuel life.

B.4.1.5 Video Visual Equipment. Underwater television cameras and lighting can be set up in

any zone in the water pools to obtain images of the external surfaces of the fuel cell assemblies and control rods. These visual inspections are used to search for anomalies such as excessive corrosion or wear on external surfaces. The bottom end of the fuel cell assemblies can also be inspected for flow blockage, corrosion, and wear.

B.4.1.6 Assembly and Disassembly Tables. These tables are used to assemble and disassemble

irradiated test assemblies that are inserted in the ATR. There are two identical assembly and disassembly tables installed side by side in the water pools. Each is mounted on a tilt platform that is used to rotate the table from a horizontal position for test assembly and disassembly to a vertical position for loading and unloading the test assembly.

B.4.1.7 Headwork Station. The Headwork Station provides containment and shielding for the

mechanical connection and disconnection of components to and from the unirradiated portion of the assembly and disassembly of irradiations tests for the ATR. There are two independent work stations; each consists of an elevator platform which raises the top unirradiated portion of the test above the water surface. A containment is positioned above the water surface to prevent the spread of contamination while the examination is performed above the water.

B.4.1.8 Fuel Storage Racks. Storage racks are required at ECF since, at times, fuel is received

into the facility faster than fuel can be prepared and shipped out of the facility. Racks are also used to store the small amount of naval spent nuclear fuel selected for retention as library specimens for future reference and study. Ensuring that the racks are conservatively designed to withstand any credible accident and continue to provide adequate nuclear separation are the major criteria for storage racks.

The basic configuration of a fuel storage rack is a rectangular structural array of storage ports. Each port has a square opening, but depth is variable. All storage ports in use at ECF are stainless steel. Stainless steel is used exclusively to resist corrosion during the life of the storage racks. The storage ports are designed to withstand the weight of the heaviest fuel module which can be placed in the port, and the frame assembly is designed to support the entire weight of all the fuel ports fully loaded with the heaviest fuel type.

All the fuel racks are designed to maintain their structural integrity during a design basis earthquake and to withstand the impact of a fuel module dropped onto the fuel racks. Analyses of all fuel racks in the event of seismic activity has demonstrated that they will not collapse during the postulated earthquake. ECF also performed a full analysis of the strength of the ports if a fuel module were dropped over the fuel racks, including the kinetic energy which the dropping fuel module would impart to the rack. It was determined that all fuel racks at ECF were adequately designed to withstand the energy of dropped fuel. The analysis also identified that some equipment handled at ECF was heavy enough that the racks might be deformed if the equipment were dropped. Thus, operating rules and procedures prohibit the movement of large loads over the fuel racks to ensure that no accidental damage to the racks can occur.

Fuel storage racks were also designed to prevent arrangement of the modules into a potentially critical configuration. The fuel racks are designed so that each port separates the module it contains from every other module by a distance great enough to prevent criticality under the most limiting conditions possible. To assure that only one piece of fuel is placed in a port, all fuel storage ports are equipped with lids which can be locked and sealed. Finally, the frame assemblies of all fuel storage racks are covered with stainless steel sheeting to prevent fuel from inadvertently being placed between fuel storage ports.

B.4.2 Water Pool to Shielded Cell Transfer Systems

Components that have been removed from spent nuclear fuel cells or test assemblies can be transferred into the shielded cells using one of the three available water pool to shielded cell transfer systems. The transfer systems use carts that are driven through underwater tunnels.

B.4.3 Shielded Cell Examination Equipment

ECF has specialized equipment installed in the shielded cells which is designed to perform examinations on fuel elements and components removed from spent fuel cell assemblies and test specimens that have been irradiated in the ATR. A description of the major shielded cell equipment follows.

B.4.3.1 Electronic Balances. These are commercially available electronic balances that have been

modified to operate remotely in the shielded cells. Components on these balances that are known to deteriorate from exposure to radiation have been replaced using materials that are less susceptible to radiation damage. The equipment is interfaced with computer data acquisition systems to aid the operators in tracking and reducing the data. These balances are used primarily to assess weight changes that result from corrosion testing of materials in the ATR.

B.4.3.2 Descale Tanks. Corrosion removal is performed for test specimens that have been

irradiated in the ATR and structural components and fuel elements removed from spent nuclear fuel modules. These tanks use heat, chemicals, and ultrasound to dislodge corrosion that has accumulated on the specimens or components. The corrosion removal aids in visual examination of these specimens.

B.4.3.3 Bridgeport Milling Machine. This is a high-precision milling machine that has been

modified for remote operation in the ECF shielded cells. The mill is controlled by a programmable controller located in the shielded cell gallery. The Bridgeport mill is used for precise machining of non-fuel components removed from spent nuclear fuel cell assemblies.

B.4.3.4 Specimen Coordinate Automated Measuring Machine. The specimen coordinate

automated measuring machine is a fully automated unit specifically designed to perform three-dimensional measurements on irradiated test specimens and structural components removed from spent nuclear fuel cells. The equipment is completely computer controlled and has an accuracy of 0.00005 inch (50 microinches). The information obtained from this equipment is used to assess the effect of radiation on material growth and fuel burnup on swelling of specimens.

B.4.3.5 Fiducial Automated Measuring Machine. This machine is used to measure the distance

between scribe marks that are put on some types of specimens during fabrication. The machine accurately measures the position of the scribe marks in relation to other fiducial marks on the specimen. These data are used to assess the effects of radiation on specimen growth and distortion, as well as the effect of fuel depletion on fuel element swelling.

B.4.3.6 Gamma Scan System. This system measures gamma radiation emitted by fission

products to identify isotopes present in the fuel as a result of fuel depletion. The system is controlled by a dedicated computer which positions the specimen, provides for data acquisition and evaluation, and provides an output of the isotopes detected by the system at each location along the axes of the specimen.

B.4.3.7 Alpha Box. The Alpha Box is a carbon steel containment inside the shielded cells. It

provides isolation within the shielded cells for fuel cutting to prevent the spread of fission products. This is the only location in the facility where cutting through the fuel region of spent nuclear fuel is allowed.

B.5 FACILITY DESIGN AND INTEGRITY REQUIREMENTS

B.5.1 Flood

A flood at ECF due to overflow of any source of surface water within the INEL boundaries is a low probability event. With the construction of the INEL flood control diversion system in 1958, the threat of a flood from overflowing of the Big Lost River, the primary source of surface water at the INEL, has become very small.

The maximum water elevation postulated at ECF would be caused by a hypothetical Probable Maximum Flood resulting from failure of the Mackay Dam, located approximately 35 miles northwest of the INEL. The hypothetical flood could result in a maximum water level approximately 3 feet above the floor elevation of the ECF building. This flood is postulated to result from water flowing over the top of the Mackay Dam and causing it to fail due to high water levels. This flood is highly unlikely. (Koslow and Van Haaften 1986)

Dam failure due to other causes, such as seismic activity, is more likely. Although the Mackay Dam survived the 1983 Borah Peak earthquake without damage, it was built without seismic design criteria. Additionally, it is not clear how resistant the dam structure is to seismic events. A fault segment runs within 6 kilometers of the Mackay Dam.

Flooding of the ECF building is possible should the Mackay Dam fail. Flooding of the ECF building would not create a nuclear criticality hazard. Flooding of the building could result in the release of water containing low levels of radioactive contamination to the environment and damage to equipment in flooded areas. Following the dam break, it would take over 16 hours for the flood water to reach NRF. This is adequate time to complete emergency procedure preparations, such as filling and placing sandbags, for the expected flood conditions.

B.5.2 Earthquake

The ECF building structure was built in accordance with the Uniform Building Code for each particular phase of construction. Water Pit No. 1, Water Pit No. 2, and Water Pit No. 3 were built to "Zone 2" earthquake requirements which were judged to be appropriate under the U.S. Geologic Survey classification of the area at the time of their construction. Water Pit No. 4 and its two transfer canals were built to the more restrictive "Zone 3" earthquake requirements in effect at the time they were built.

A seismic assessment has been performed for the ECF using the actual characteristics of the existing facility. Based on this assessment, a design basis seismic event at ECF could have a peak ground acceleration of 0.24 g (Rizzo 1994). This peak ground acceleration is derived on the basis that a moment magnitude 6.9 seismic event centered near Howe on the Lemhi fault would cause a rupture of approximately 34 kilometers along the Lemhi fault. The Howe epicenter is the epicenter located closest to ECF, and 6.9 was the moment magnitude of the Borah Peak earthquake in 1983. This approach for postulating the location of the seismic event is consistent with the Nuclear Regulatory Commission methodology used for commercial power plants. The beyond design basis seismic event was based on the entire 150 kilometers of the Lemhi fault rupturing. This beyond design basis earthquake might have a peak ground acceleration of 0.4 g at ECF.

B.5.3 Tornado

A tornado at ECF is a low probability event. The document "Technical Basis for Interim Regional Tornado Criteria," WASH-1300, provides the technical basis for Nuclear Reactor Commission Regulatory Guide 1.76, "Design Basis Tornado for Nuclear Power Plants." The WASH-1300 document identifies the probability of occurrence of a tornado at ECF to be 7.8 x 10-5 per year based on historical records. Regulatory Guide 1.76 identifies the maximum wind speed appropriate to ECF to be 240 mph. Data collected by Dr. T. Fugita of the University of Chicago performed at the request of the DOE for the period between 1950 and 1976 indicate the probability of a tornado with winds of that speed occurring at the INEL is about 1.3 x 10-9 per year. Based on a threshold wind speed for tornado damage of 75 mph (refer to P. L. Doan, "Tornado Considerations for Nuclear Power Plant Structures," Nuclear Safety, Volume 11, No. 4) and a probability of 0.80 for the occurrence of tornado-induced wind speeds greater than or equal to 75 mph (WASH-1300, Table 3), the probability of a damaging tornado occurring at ECF is 7.8 x 10-5 per year x 0.80 = 6.2 x 10-5 per year.

A tornado could not affect the fuel storage area in ECF in such a way that the fuel would be rearranged into a critical configuration. The article by Doan cited above analyzes the effects of tornados for the general case of spent fuel in water pools and concludes "... massive loss of water due to either tornado-induced wind forces or tornado-generated missiles cannot happen. It is credible, however, that a couple of feet of water could be lost owing to the combination of water splashing, water entrainment, and pressure differentials. The spent fuel at the bottom of the water pools would, however, remain completely covered.... By the same token, the radiation dose level above the water surface would not increase by any meaningful amount."

B.5.4 Fires

The entire ECF facility is protected against fires by one of several types of sprinkler systems. A large, intense fire in fuel handling areas is a low probability event because of the nature of the materials of construction in these areas, the amounts and kinds of material present, and the fire protection system. Most of the spent fuel is under many feet of water, providing additional protection against a fire which might involve fuel. Fires at other locations in the facility would be extinguished by the sprinkler system and by manual fire protection equipment (e.g., fire extinguishers or fire hoses). An extensive fire involving the ECF building structure is highly unlikely because it has been constructed of non-combustible or fire-resistive material to the greatest extent possible, in accordance with applicable Atomic Energy Commission, Energy Resource and Development Administration, and DOE design criteria.

B.5.5 Loss of Water Pool Water

Loss of all water in a section of the water pool is extremely unlikely. However, should a heavy object be dropped onto a water pool floor, a crack could develop. If this were to occur, the cracked water pool area would be isolated and drained in a controlled manner to one of the retention basins before a substantial loss of water to the environment would occur. Even in the event that severe damage to a water pool floor were to result in the loss of substantial amounts of water pool water, no nuclear criticality hazard would result and no melting of fuel would occur.

B.6 CRITICALITY CONTROL

There has never been an inadvertent criticality at the Expended Core Facility. This is the result of strict application of the following principles.

A fundamental principle of nuclear safety is Criticality Control. When a mass of nuclear fuel reaches a condition at which its atoms are capable of undergoing a self-sustaining chain reaction, or splitting (fissioning) into new elements, the result is called a criticality. Nuclear fission releases energy in the form of radiation and heat. Controlled criticality within a shielded reactor vessel produces energy within a confined space without harm to personnel or the environment. Although the water pools, the shielded cells, and the ECF building are designed to shield and contain radiation and radioactive contamination, an uncontrolled criticality (or nuclear excursion) within ECF is unacceptable, and comprehensive measures are taken to prevent such an occurrence. Criticality control at ECF could be described more accurately as "absolute criticality prevention." Conditions are identified, equipment or processes are designed, rules and procedures are formulated, and personnel are trained to prevent occurrence of an accidental criticality.

Safety analyses are performed on all fuel types and system designs where all single plausible and unlikely accidents are considered. Conservatism is employed in establishing limits and controls, and spent fuel is handled to the more restrictive as-built values. Then a "double accident criterion" is applied to all fuel handling equipment and procedures. The double accident criterion states

"Fuel must be handled and equipment designed so that acceptable margins to criticality exist after two most limiting, unlikely, independent, and concurrent accidents. In this context, two errors in a routine administrative procedure are considered to be a single accident, not two." As a result of application of this criterion to equipment and procedures at ECF, the amount of fuel which may be handled in any operation is typically restricted to one quarter of the minimum amount which could achieve criticality minus a safe margin to criticality.

All nuclear fuel operations must be performed in accordance with approved criticality control procedures. Nuclear safety analyses are carefully reviewed by the responsible management and two independent nuclear safety committees. Naval Reactors must approve each analysis before it is used. Strict reviews and approvals are also applied to implementation of safety analyses in fuel handling procedures.

The successful criticality control program at ECF is also due to thorough training and supervision of fuel handling personnel. Employees are educated concerning the principles of criticality, associated hazards, and prevention. A system of checks to ensure that the rules and limits are strictly observed is employed. It includes detailed training documentation, qualification and testing standards, a self-assessment (audit) program, and an array of accountability and nuclear safety drills.

B.7 PROPOSED DRY CELL FACILITY

The Dry Cell Facility consists of a shielded, radiologically controlled area with remotely operated equipment. The facility is designed for a 40-year life, built of structural steel and concrete, and would be integral with the existing ECF building.

The major element of the Dry Cell Facility is a large reinforced concrete shielded cell with interior dimensions of 22 feet wide by 84 feet long by 21 feet high, containing all the equipment necessary to inspect and disassemble fuel modules. The facility will have the capability to prepare and load one fuel module per shift in a shipping cask. Based on a two shift per day operation (500 shifts per year), and a 25-percent maintenance downtime, the Dry Cell Facility yearly capacity is expected to be 375 modules. Shielded decontamination and repair cells will be attached to the main shielded cell to allow remote decontamination and repair of equipment used throughout ECF. Artist's views of the Dry Cell Facility and the associated Cask Loading System are shown in Figures B-5 and B-6.

The dry cell design incorporates 4-foot thick, radiation shielding walls constructed of high-density and normal-density concrete. The shielding is designed to limit radiation levels in normally occupied areas around the cell to 0.1 millirem per hour or less. At the INEL Site boundary, there would be no measurable elevation above the naturally occurring background radiation levels. The dry cell design meets the latest seismic requirements and includes negative pressure air ventilation for radiological contamination control. Shielded lead glass windows and viewing aids are provided as required at the workstations. Power, lighting, and a fire suppression system are also provided.

The Dry Cell Facility is also designed to facilitate decontamination and decommissioning of the facility at some future date. This is achieved by including cell liner contamination barriers, no fixed embedded piping, a minimum of cracks and crevices, smooth surfaces, and wall penetrations large enough to be radiologically surveyed to verify decontamination effectiveness.

B.8 REFERENCES

Koslow, K. N. and D. H. Van Haaften, 1986, Flood Routing Analysis for a Failure of Mackay Dam, EGG-EP-7184, EG&G Idaho, Inc., Idaho Falls, Idaho, June.

Rizzo (Paul C. Rizzo Associates), 1994, Natural Phenomena Hazards - Expended Core Facility, Idaho National Engineering Laboratory, Monroeville, Pennsylvania, June.

ATTACHMENT C - COMPARISON OF STORAGE IN NEW WATER POOLS VERSUS DRY CONTAINER STORAGE

Figure B-5. Proposed ECF Dry Cell Facility. Figure B-6. ECF Dry Cell Facility Cask Loading System.

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ATTACHMENT C

COMPARISON OF STORAGE IN
NEW WATER POOLS VERSUS
DRY CONTAINER STORAGE

C.1 INTRODUCTION

This attachment discusses the advantages and disadvantages of water pools versus dry container storage should construction of additional interim storage be required. The discussion considers the generic safety aspects of water pools and dry container storage based on evaluations performed by the Nuclear Regulatory Commission (NRC) and the Department of Energy (DOE) as well as experience with naval spent nuclear fuel.

C.2 WATER POOLS

During the last four decades, the Expended Core Facility (ECF) at the Idaho National Engineering Laboratory (INEL) has demonstrated the safety and reliability of water pools under the control of the Naval Reactors Program. Water pools have historically been the method of choice for interim storage and fuel handling because: (1) water has a high thermal capacity for the removal of heat from the fuel, (2) the transparency of water facilitates the inspection and movement of the fuel, (3) water is an excellent gamma and neutron shield, (4) water is easy to purify and recycle, and (5) water provides a means to prevent release of radioactive material into the air.

The safety of spent fuel storage in a water pool can be considered in terms of three generic criteria. They are: (1) the integrity of spent fuel under water pool storage conditions, (2) the structure and component safety of the facility, and (3) the potential risks of accidents and acts of sabotage at the spent fuel facility.

The NRC conducted an extensive investigation into the storage of spent fuel and documented the findings in the Waste Confidence Decision (NUREG 1984). Based on the technical evaluations cited in that document, the NRC found that the Zircaloy cladding which encases spent fuel is highly resistant to failure under pool storage conditions and concluded that Zircaloy-clad commercial fuel satisfied the first generic criterion. This conclusion is consistent with the extensive experience with naval spent nuclear fuel. Naval fuel is Zircaloy clad and thus is highly resistant to corrosion in water. In addition, a Navy fuel assembly has much higher mechanical integrity than commercial fuel since it is designed for military application and is capable of withstanding shock loadings which may be encountered in battle conditions.

The NRC also conducted an extensive evaluation of the structural and component safety of water pools. The NRC found no reason why spent fuel storage pools would not be capable of performing their cooling and storage functions for a number of years past the design life of 40 years if the water pools are properly maintained; therefore, the second generic criterion would be satisfied. This conclusion is consistent with the naval fuel experience of over 35 years of operation of the ECF.

The risk of major accidents at spent fuel storage pools resulting in off-site consequences is remote because of the secure and stable character of the spent fuel in the storage pool environment, and the absence of driving forces (i.e., high pressure or temperature) which might result in dispersal of radioactive material (NUREG 1984). The consequences of terrorist attacks on a spent fuel storage pool would be limited by the realities that the radioactive content of spent fuel is in the form of material encapsulated in high-integrity metal cladding and stored underwater in a reinforced concrete structure. Under these conditions, the radioactive content of spent fuel is relatively invulnerable to dispersal to the environment (NUREG 1984).

These considerations led the NRC to conclude that storage pools can be designed to safely withstand accidents caused either by natural or man-made phenomena such that there would be no impact to the environment. Therefore, the third generic criterion would be satisfied.

The NRC concluded that all areas of safety and environmental concern (e.g., maintenance of systems and components, prevention of material degradation, protection against accidents and sabotage) have been addressed for water pools, and that spent fuel can be stored with no environmental impact. This conclusion is supported by the Organization for Economic Co-Operation and Development of the Nuclear Energy Agency (NEA 1993).

C.3 DRY CONTAINER STORAGE

Dry container storage technologies have been in use in the United Kingdom since 1972 (MOCSG 1993). In the United States, demonstration projects have been underway since 1982. In dry container storage, multiple barriers prevent gaseous as well as particulate fission product releases. Two separate barriers must fail before fission products can be released: (1) the fuel cladding, and (2) the outer secondary seal. In addition, dry storage systems provide metal or concrete shielding to reduce the external radiation to acceptable limits.

The NRC concluded that dry container storage involves a simpler technology than that represented by water storage systems. Water storage relies to a certain extent upon active systems such as pumps, renewable filters, and cooling systems to maintain safe storage. Favorable water chemistry must also be maintained to retard corrosion. Dry container storage uses convective circulation of an inert atmosphere in a sealed dry system so there is little opportunity for corrosion (NUREG 1984).

The NRC also found that dry container storage of spent fuel in dry wells, vaults, silos, and metal casks is relatively invulnerable to sabotage and the forces of nature, because of the weight and size of the sealed, protective enclosures, which may include 100-ton steel casks, large concrete-lined casks, and surface concrete silos (NUREG 1980).

The NRC concluded that for dry interim storage, all areas of safety and environmental concern (e.g., maintenance of systems and components, prevention of material degradation, protection against accidents and sabotage) have been addressed and shown to present no more potential for adverse impact on the environment and the public health and safety than storage of spent fuel in water pools. This conclusion is supported by the Organization for Economic Co-Operation and Development of the Nuclear Energy Agency (NEA 1993).

As stated earlier, naval fuel uses Zircaloy cladding and has a much higher mechanical integrity than commercial fuel since naval fuel is designed for military application. Therefore, the generic conclusions reached for commercial spent fuel are directly applicable to naval spent fuel.

C.4 NON-RADIOLOGICAL CONSEQUENCES OF SPENT FUEL

STORAGE

The NRC concluded (NUREG 1984) that "there are no significant non-radiological consequences due to the extended storage of spent fuel which could adversely affect the environment." The construction of an interim spent fuel storage facility (i.e., the construction of a water pool, a concrete pad, a building, rail spur, etc.) would have little impact on the environment. The amount of heat given off by spent fuel decreases with time as the fuel ages and decays radioactively, and the amount of additional energy and water needed to maintain spent fuel storage is also small.

C.5 LAND UTILIZATION

With the use of water pool storage or dry container storage at an existing shipyard, land already devoted to industrial use is planned to be used for the spent fuel storage facility. The amount of land required for storage at specific shipyards is addressed in Attachment D.

C.6 COST

The use of alternate sites other than INEL would involve the construction of additional storage facilities. Both water pools and dry container storage could be used, with little environmental impact; therefore, the relative cost between these two options could be relevant. Conceptual cost estimates have been prepared for each storage option at each location that is being evaluated. These cost comparisons are found in Attachments D and E.

C.7 SUMMARY

Based on the above discussion, both a new water pool and dry container storage would be suitable for the interim storage of spent naval fuel with no important radiological or non-radiological environmental impact. If a facility would be required to be used for the inspection of spent fuel, as well as storage, then a water pool offers an advantage since water is an inexpensive and convenient form of transparent shielding. If it were not necessary for a new facility to be used to inspect spent fuel, then the cost of the facility and the amount of land required could be factors in selecting an option.

C.8 REFERENCES

MOCSG (The Midwestern Office of the Council of State Governments), 1993, Report on Interim Storage of Spent Nuclear Fuel, DOE/CH/10402--22, April.

NEA (Nuclear Energy Agency), 1993, The Safety of the Nuclear Fuel Cycle, Organization for Economic Co-Operation and Development.

NUREG (U.S. Nuclear Regulatory Commission), 1980, Dry Storage of Spent Nuclear Fuel, NUREG/CR-1223, April.

NUREG (U.S. Nuclear Regulatory Commission), 1984, "Waste Confidence Decision," Federal Register, Volume 49, No. 171, August 31.

ATTACHMENT D - DESCRIPTION OF STORAGE OF NAVAL SPENT NUCLEAR FUEL

AT SERVICING LOCATIONS (SHIPYARDS AND PROTOTYPES)

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D.1 STORAGE OF NAVAL SPENT NUCLEAR FUEL IN CONTAINERS AT SHIPYARDS AND PROTOTYPES

D.1.1 Introduction

This attachment examines the alternative of storing naval spent nuclear fuel at shipyard and prototype sites where the fuel is removed from the reactor plant. Water pool storage, immobile dry storage containers, and dry storage in shipping containers are evaluated for each shipyard and prototype location. Under the No Action alternative, naval spent nuclear fuel would be stored in shipping containers. For the other alternatives where naval spent nuclear fuel would be stored at shipyard and prototype sites, the storage mode would be selected by the Record of Decision. Attachment C has addressed the generic safety of water pool and dry storage and concluded that both methods would be suitable for the interim storage of naval spent nuclear fuel with very little environmental impact. This attachment addresses the design requirements, operational considerations, costs, and land requirements for the Puget Sound Naval Shipyard, Pearl Harbor Naval Shipyard, Norfolk Naval Shipyard, Portsmouth Naval Shipyard, and the Kesselring Site.

The interim storage facilities for naval spent nuclear fuel at shipyards and prototype locations would be designed to comply with applicable requirements. The storage facilities would be monitored and maintained in compliance with Naval Reactors Program requirements for radiation protection of workers and the public and the environment. Specifically, exposure to workers at the storage site would be maintained as low as reasonably achievable and would be controlled to Naval Reactors Program radiation exposure standards. As with current naval practices, no measurable increase in radiation levels at the site boundary would result from the storage of naval spent nuclear fuel at any alternate site.

D.1.2 Shipping Containers

D.1.2.1 Container Design Features. Shipping containers and immobile dry storage containers

position the spent naval fuel modules within sealed structures designed to physically constrain, support, and remove residual heat from the fuel in an environment that prevents corrosion of the fuel. The massive size of the containers provides not only strength, but also shielding against exposure to radiation from the spent fuel within.

The shipping containers might be M-140 shipping containers with long-lived seals suitable for storage of spent nuclear fuel for the duration of the period covered by this Environmental Impact Statement (EIS). A description of the M-140 shipping container is provided in Attachment A. This container is already certified to meet the requirements of the U.S. Nuclear Regulatory Commission, contained in 10CFR71, for the transportation of naval spent nuclear fuel. With installation of a long-lived seal, the M-140 container could be qualified for storage for 40 years. The shipping containers could either be positioned on railcars at the storage site or on concrete pads. The process of designing the shipping container long-lived seal would commence with the Record of Decision if this option were selected. The cost associated with the design and recertification of the shipping container would range from approximately $1 million to $5 million. The cost to manufacture each shipping container would be about $5 million. Some uncertainties in estimated costs exist due to the fact that a detailed design for the shipping container long-lived seal is not yet available.

If the Record of Decision were to choose shipping containers, a more detailed evaluation would need to be performed to determine whether it is more appropriate to modify the M-140 shipping container design or whether a new container design should be used. Since the M-140 was designed as a shipping container, the modifications that would need to be made to convert an M-140 to accommodate interim storage might involve substantial new design work and recertification for shipping.

About 500 additional containers with holding capacity equivalent to the M-140 container would need to be fabricated to cover the projected reactor servicing from 1995 through 2035. If an alternative using the shipping containers were to be chosen, an expanded manufacturing vendor base would need to be developed to meet the projected container requirements. With the current manufacturing capabilities, 3 years are required to build an M-140 container and the output capacity is about 6 containers per year.

The shipping containers loaded during the period preceding the Record of Decision would also need to be modified to meet the storage container design criteria. An evaluation would be performed to determine whether these modifications could be safely made with spent nuclear fuel present in the containers. In the event that the spent nuclear fuel must be removed from the shipping containers, the containers would be unloaded and the spent nuclear fuel would be transferred into modified shipping containers at a suitable facility under controls which would protect workers, the public, and the environment. The unloading of spent nuclear fuel from the original shipping containers and reloading into modified shipping containers would introduce additional spent nuclear fuel handling, transportation, and risks.

D.1.2.2 Operations. The process of loading spent nuclear fuel into shipping containers for storage

would be similar to that used for loading M-140 shipping containers. During reactor refueling operations, spent nuclear fuel is normally loaded into M-140 shipping containers that are filled with water. The spent nuclear fuel is staged in this configuration for sufficient time to ensure that heat produced by radioactive decay of fission products is adequately dissipated. When the water is removed from the M-140 container, the loaded M-140 can be shipped. After water is drained from the shipping container, it would be transported to the storage site. The water is processed for reuse.
The transportation procedures would be essentially unchanged from current procedures except that containers would be moved to the interim storage site instead of being shipped to the Expended Core Facility (ECF) at the Idaho National Engineering Laboratory (INEL) for inspection. For railcar storage, the railcar would be positioned in the storage area. For cases where the shipping container is stored on a concrete pad, the container would be off-loaded from the railcar or truck, positioned, and then secured to the pad (if securing would be required). In order to accomplish this transfer, a large capacity crane would be needed at each site, and the site would need to be prepared as necessary to accommodate the mode of storage.

D.1.3 Immobile Dry Storage Containers

D.1.3.1 Container Design Features. There are currently no immobile dry storage containers

designed for interim storage of naval spent nuclear fuel. The container design would be similar to that of containers which are presently certified by the Nuclear Regulatory Commission for storage of spent nuclear fuel from commercial reactors. The design, approval, and construction of an immobile dry storage container would commence with the Record of Decision if this option were selected. This effort could require up to 5 years to complete. The cost associated with the design and approval of the immobile storage container would be about $2 million. The cost to construct each immobile dry storage container would be about $2 million. These estimates are based on costs of commercially available containers with contingencies added to account for additional design features that may be required.

Two concepts for storing naval spent nuclear fuel in immobile dry storage containers have been developed in order to provide a baseline for assessing the impacts. Other dry storage approaches (such as dry storage vaults) exist and would be considered in more detail if the Record of Decision were to choose the immobile dry container storage alternative. The first approach (referred to as the minimum fuel loading concept) is based on the number of spent fuel assemblies stored in the immobile dry storage container being about the same as that which is loaded into M-140 shipping containers. This approach results in the need for about 500 immobile dry storage containers. The second approach (referred to as the maximum fuel loading concept) maximizes the number of fuel assemblies that would be stored in the immobile dry storage containers. The number of containers required for the second approach is about 300.

The minimum fuel loading concept results in a container with a comparatively simpler

design, less maintenance, and lower unit costs (~$1.9 million/container). Under the maximum fuel loading concept, the container would need to be equipped with additional active cooling features such as water circulation to ensure that the heat produced by radioactive decay of fission products is adequately removed. These additional cooling features would be needed for a period of several years after the spent nuclear fuel is removed from the reactor vessel. For the minimum fuel loading concept, additional active cooling features such as recirculating water would not be required to remove heat.
As with the shipping containers, an expanded vendor base would be necessary in order to construct the immobile dry storage containers at the rate they would be needed.

Figures D-1 and D-2 provide conceptual layouts of candidate immobile dry storage containers for naval spent nuclear fuel.

Figure D-1. Conceptual concrete immobile dry storage container for naval spent nuclear fuel.

Figure D-2. Conceptual vertical metal immobile dry storage container for naval spent nuclear fuel.

The dimensions of the immobile dry storage container that would be used for naval spent nuclear fuel would be approximately the same as the M-140 shipping container (i.e., approximately 10 to 16 feet high and 8 to 10 feet wide). The fuel spacing within the container and the container itself would be designed to prevent any nuclear chain reaction, to ensure that decay heat is adequately dissipated, and to ensure that the spent fuel would be protected from hazards associated with natural phenomena or human activities for each storage site.

D.1.3.2 Operations. Operations commence following the defueling of the reactor, after fuel

modules are in a suitable holding container such as an M-130 or M-140 shipping container. The immobile dry storage container would be positioned at the storage location. Transfer of a spent fuel module from the holding container to the dry storage container would be accomplished one fuel module at a time using a shielded transfer container. All fuel transfers would be conducted in strict accordance with procedures which would have been written, reviewed, and approved by personnel trained, qualified, and specifically authorized to perform such work. The transfer container would be landed on the holding container, and a module would be withdrawn from the holding container. The module would be secured and the loaded transfer container closed, moved into position over the dry storage container, and landed. The transfer container would be reopened and the module lowered and seated in the immobile storage container. The transfer container would then be removed. This process would be repeated until the container is filled with spent fuel modules. The container would then be sealed.

Transfers of spent nuclear fuel to the immobile dry storage container would be conducted in accordance with Naval Reactors Program requirements for radiation protection. Radiological containment devices would be used where necessary to prevent radioactivity from spreading to the workplace and from becoming airborne. The transfer and storage containers would contain radiation shielding that minimizes radiation exposure to the workers during transfer and storage operations and ensures that radiation levels at the site perimeter are indistinguishable from natural background.

D.1.4 Water Pool Storage

D.1.4.1 Water Pool Design Features. If the Record of Decision were to choose the alternative of

storing naval spent nuclear fuel in water pools, five water pools could be constructed, one at each designated storage site. Each water pool facility would be designed, built, and operated in accordance with DOE Order 6430.1A and consistent with the intent of Nuclear Regulatory Commission requirements in 10CFR72 and associated Regulatory Guides. The siting, design, construction, and approval of a water pool storage facility would commence with the Record of Decision and could take 6 to 9 years to complete. The design and construction of each water pool facility would also conform with local construction standards for each site.

Water pools operate by holding spent fuel modules in a deep pool of water. The water provides cooling for the spent fuel, a transparent medium for work activities, and protection from radiation (see Attachment C). The structural materials of the fuel modules and naval fuel cladding, as well as temperature and chemistry control of the water, would result in the spent fuel being highly resistant to corrosion. Corrosion-resistant racks below the water surface would be used to support and position the fuel modules in place for handling and to prevent a critical mass being formed. The water depth would be sufficient to provide shielding to protect workers and the environment during module movement and storage.

D.1.4.2 Operations. The naval spent nuclear fuel would be transferred to the water pool in a

suitable container, such as an M-130 or M-140 shipping container. The fuel modules would then be transferred into the water pool using equipment and procedures that are similar to well-proven procedures used at ECF for unloading spent nuclear fuel from shipping containers. The spent nuclear fuel modules would be individually lowered and secured in the storage racks located on the water pool floor. The use of a water pool for storage of naval spent nuclear fuel would provide an opportunity for limited visual inspection of the exterior of the fuel modules after removing them from the naval vessels. This opportunity would not exist to the same extent for the dry storage container alternatives.

D.1.5 Design Basis Considerations for Storage Containers and Water

Pools

The design of both the shipping and immobile dry storage containers would be in accordance with DOE Order 6430.1A and consistent with the intent of Nuclear Regulatory Commission requirements for independent spent fuel storage installations found in 10CFR72 and associated Regulatory Guides. Attachment F describes the exposures which would be expected during normal operational exposures and the exposures calculated for hypothetical accidents that might occur during interim storage of spent fuel at each shipyard and prototype location. The accidents that would be used to establish the requirements for the design of the interim storage facilities are discussed below.

D.1.5.1 Design Basis Considerations for Storage Containers.

(1) Natural Phenomena. The fuel spacing within the container and the container itself would be designed to prevent a nuclear criticality, to ensure that heat produced by radioactive decay of fission products is adequately dissipated, and to ensure that the container would safely survive hazards associated with natural phenomena such as storms or flooding for each storage site. The shipping containers and the immobile dry storage containers would be designed to withstand the most severe design basis seismic event expected for the storage sites. The seismic analysis would evaluate the internal and external structures of the containers and the components associated with stability of the containers. The containers and associated components would be designed to protect the environment during other natural phenomena such as tornado winds, tornado missiles, hurricanes, volcanic activity, design basis floods, and very large waves. If the Record of Decision involves the need for new facilities for the interim storage of naval spent nuclear fuel, detailed site-specific seismic evaluations would be conducted for those sites, and the results would be incorporated into the design of new facilities. The construction of any new facilities for naval spent nuclear fuel management would meet strict seismic standards for the interim storage of naval spent nuclear fuel. The design and construction of these facilities to seismic standards which take into consideration the seismic character of the area would ensure that structures could withstand a major seismic event. The adequacy of the storage facility would be documented in a safety assessment report for each location.

(2) Man-made Hazards. The containers would be arranged to allow access for routine inspections, maintenance, and emergencies. This includes sufficient accessibility for pressure, temperature, and radiological monitoring as well as for fire fighting equipment and ambulances.

The containers would be designed to withstand a fire without losing fission product containment. Flammable liquids and gases as well as explosive materials would be prohibited in the storage area with the exception of fuel in motor vehicles needed to support operations. Combustible materials such as wood, paper, and plastic would be kept to a minimum in the spent nuclear fuel storage areas.

The fuel spacing within the container and the container itself would be designed to prevent nuclear criticality, to ensure that the heat produced by radioactive decay is adequately dissipated, and to ensure that it would safely survive credible man-made accidents for each storage site. Other man-made hazards such as truck accidents, airplane crashes, and objects dropped by cranes would also be addressed in the safety assessment report.

D.1.5.2 Design Basis Considerations for Water Pools.

(1) Natural Phenomena. The spent nuclear fuel spacing within the water pool and the water pool itself and the building support structures would be designed to prevent criticality, to ensure that heat produced by radioactive decay is adequately dissipated, and to ensure that it would protect the fuel from the hazards associated with the design basis natural phenomena for each storage site (i.e., seismic, tornados, missiles generated by a tornado, hurricanes, volcanic activity, maximum expected floods, and very large waves). The water pools would be equipped with spent fuel storage racks for restraining the modules. The racks would be designed to safely survive the above hazards. If the Record of Decision involves the need for new facilities for the interim storage of naval spent nuclear fuel, detailed site-specific seismic evaluations would be conducted for those sites, and the results would be incorporated into the design of new facilities. The construction of any new facilities for naval spent nuclear fuel management would meet strict seismic standards for the interim storage of naval spent nuclear fuel. The design and construction of these facilities to seismic standards which take into consideration the seismic character of the area would ensure that structures could withstand a major seismic event. The adequacy of the water pool facility would be documented in a safety assessment report for each location.

(2) Man-made Hazards. The water pool facility would be designed to withstand fire without damage to the spent fuel within the water. Flammable liquids and gases as well as explosive materials would be prohibited in the vicinity of the storage area with the exception of incidental quantities of flammable solvents necessary to support operations. Combustible materials such as wood, paper, and plastic would be kept to a minimum in the water pool facility.

The fuel spacing within the water pool would be designed to prevent criticality, and to ensure that it would safely survive credible man-made accidents for each storage site. Other man-made hazards such as truck accidents, airplane crashes, and crane drop accidents would also be addressed in the safety assessment report.

D.1.6 Shipyard and Prototype Locations

This section describes conceptual locations at the shipyard and prototype sites where storage facilities could be located to service refuelings and defuelings of naval ships. This section also lists land requirements for each storage method at each location, the construction cost for each method, and the associated operating cost.

D.1.6.1 Land Requirements. This section provides a summary of the land required for each of

the storage methods at each of the locations where refueling and defueling are planned from 1995 through 2035.

These locations are the Portsmouth Naval Shipyard, the Puget Sound Naval Shipyard, the Pearl Harbor Naval Shipyard, the Norfolk Naval Shipyard, and the Kesselring Site. A map of each of these sites is provided in Figures D-3 through D-7, indicating a possible storage location at each of these facilities.

Figure D-3. Conceptual location of the interim storage site at Puget Sound Naval Shipyard. Figure D-4. Conceptual location of the interim storage site at Norfolk Naval Shipyard. Figure D-5. Conceptual location of the interim storage site at Kesselring Prototype Site. Figure D-6. Conceptual location of the interim storage site at Pearl Harbor Naval Shipyard. Figure D-7. Conceptual location of the interim storage site at Portsmouth Naval Shipyard. Table D-1 provides a summary of the amount of land needed for each of the storage methods at each of the locations where storage of naval spent nuclear fuel could be located. It should be noted that the number of containers and land required could be slightly less than identified in Table D-1 as a result of actions taken during the transition period. As shown in Table D-1, storage utilizing shipping containers on railcars would typically require dedication of the most land.

Table D-1. Square feet of land required for storage facility.

Pool Facility(4) Location	Number of Immobile Dry Storage Containers(1)	Number of Shipping Containers	Immobile Dry Storage Containers(2) (ft2)	Shipping Containers on Concrete Pad(3) (ft2)	Shipping Containers on Railcars (ft2)	Water (ft2)
Portsmouth	27-51	61	10,000-19,000	18,000	72,000	20,000
Puget Sound	153-206	219	57,000-77,000	64,000	260,000	33,000
Pearl Harbor	21-30	42	8,000-11,000	12,000	50,000	20,000
Norfolk	132-219	247	49,000-82,000	72,000	293,000	31,000
Kesselring	5-6	6	1,900-2,000	1,700	7,100	17,000

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(1) Range in required number of containers is due to options in conceptual design (see Section D.1.3.1).

(2) The immobile dry storage arrangement uses the containers stored on a concrete pad in double rows with one container diameter separation between adjacent containers. Each row is separated by a 15-foot wide accessway. Range in required land area is due to options in conceptual design.

(3) The shipping container arrangement uses the containers stored on a concrete pad in double rows with 4 feet between adjacent containers. Each row is separated by a 15-foot wide accessway.

(4) The water pool facility consists of a building that contains adequate space to house supporting equipment and facilities (approximately 17,000 ft2) and a water pool with adjacent work areas of sufficient size to accommodate the amount of spent nuclear fuel expected to be stored in the facility until 2035.

D.1.6.2 Site Construction, Container, and Operating Costs. This section provides estimated

costs associated with each alternative for storing spent nuclear fuel at the shipyard and prototype sites. The major cost factors include facility construction or site preparation costs, container costs, and operating costs over the lifetime of the facility. Cost estimates are based on 1995 dollars.

Table D-2 provides a summary of the estimated construction costs for each storage option at each shipyard and prototype location. The construction costs for immobile and shipping containers on concrete pads and shipping containers on railcars include estimated costs for concrete (labor and materials), rails (for railcars), or cranes for lifting and handling containers or fuel transfer containers (for concrete pad storage). The majority of the construction costs for concrete pad storage options

Table D-2. Estimated site construction costs (millions of dollars).

Location	Immobile Dry Storage Containers on Concrete Pad	Shipping Containers on Concrete Pad	Shipping Containers on Railcars	Construction and Installation of Water Pools
Portsmouth	11-12	10	2	96
Puget Sound	15-16	13	5	141
Pearl Harbor	10-11	9	1	95
Norfolk	14-17	14	6	135

Kesselring	10	8	1(1)	89
Total	60-66	54	15	556

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(1)Estimate does not include costs associated with establishing railroad extension from the access railroad to the storage site.

are associated with the need for a high-capacity crane. Water pool construction costs include estimates of costs for construction of the water pool, building structure, and associated support equipment. The table shows that construction costs for a water pool facility exceed those of other alternatives, and that shipping containers on railcars involves the lowest construction costs. However, the water pool facility construction costs represent a complete facility ready to hold spent nuclear fuel for interim storage. The construction costs in Table D-2 for the other storage modes represent completed site construction without the cost of the containers (see Table D-3) to hold the spent nuclear fuel.

Table D-3 provides a summary of the estimated costs to build shipping containers and immobile dry storage containers through 2035. The table shows that the immobile dry storage containers are the least expensive containers, and that the cost to build shipping containers to rest on concrete pads is slightly lower than to rest on railcars. The difference in cost between the two shipping container options is due to the cost of a dedicated railcar during storage. The shipping container costs in Table D-3 would be reduced by about 13 percent due to actions taken during the transition period (these actions are described in Section 3.8) to ship containers from the shipyards to ECF. Consequently, the total costs for shipping containers on concrete pads and shipping containers on railcars considering the transition period would be about 2615 and 2760 million dollars, respectively.

Table D-3. Estimated container cost (millions of dollars).

Location	Immobile Dry Storage Containers on Concrete Pad(1)	Shipping Containers on Concrete Pad	Shipping Containers on Railcars(2)
Portsmouth	55-100	319	337
Puget Sound	314-406	1145	1209
Pearl Harbor	43-59	220	232
Norfolk	271-431	1292	1363
Kesselring	10-12	31	33
Total	693-1008	3007	3174

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(1)Range in container costs due to options in conceptual designs (see Sections D.1.2.1 and D.1.3.1). The lower end of the range represents container costs for the maximum fuel loading option (which requires fewer containers).

(2)Includes the cost of an equal number of railcars and containers required for this option.

Table D-4 provides the estimated costs to operate a naval spent nuclear fuel storage area. The operating costs include estimates of cost for personnel to monitor the facility, handle the spent nuclear fuel when it arrives at the facility, and maintain the facility. These estimates do not include the costs associated with eventual preparation of spent fuel for shipment to a site for disposition. Disposition preparation costs cannot be estimated at this time because the method for preparing the spent fuel has not been defined. Table D-4 shows that the lowest operating costs are associated with shipping containers on concrete pads and that water pool storage requires the highest operating costs.

Table D-4. Estimated operating costs through the year 2035 (millions of dollars).

Location	Immobile Dry Storage Containers on Concrete Pad	Shipping Containers on Concrete Pad	Shipping Containers on Railcars(2)	Water Pool
Portsmouth	11	3	8	180
Puget Sound	23	4	24	206
Pearl Harbor	11	3	6	180
Norfolk	21	4	27	206
Kesselring	9	2	3	124
Total	75	16	68	896(1)

(1)For comparison, the estimated operating cost (personnel to monitor and handle fuel and maintain the facility) for the ICPP Building 666 for the same period is 232 million dollars.
(2)Includes cost to replace or refurbish railcar after prolonged storage.

D.1.6.3 Total Construction and Operating Costs. Table D-5 is a compilation of the data

contained in Tables D-1 through D-4, and calculated based on the entire 40-year period from the Record of Decision (1995 through 2035). This table shows that the total costs associated with the use of immobile dry storage containers are the lowest of all the storage options considered except for storage at Puget Sound and Norfolk where the largest amounts of spent fuel would be stored. In these cases, the total costs for using water pool storage are within the same range of approximation as immobile dry container storage.

Table D-5. Total costs through the year 2035 (millions of dollars).

Location	Immobile Dry Storage Containers on Concrete Pad(1)	Shipping Containers on Concrete Pad	Shipping Containers on Railcars	Water Pool
Portsmouth	77-123	332	347	276
Puget Sound	352-445	1162	1238	347
Pearl Harbor	64-81	232	239	275
Norfolk	306-469	1310	1396	341
Kesselring	29-31	41	37	213
Total Cost	828-1149	3077	3257	1452

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(1)Range in total costs due to options in conceptual design (see Section D.1.3.1). The lower cost is associated with the maximum loading concept.

D.1.7 Time Required to Implement Each Storage Method

If the Record of Decision were to choose one of the alternatives involving storage of naval spent nuclear fuel at shipyards and prototype sites, some period of time would be required after the decision to fully implement the selected storage alternative. This section examines the time required to implement each storage method.

D.1.7.1 Container Storage. Implementation of the alternatives involving use of immobile dry

storage containers and shipping containers could be viewed as a three-phase process. The first phase would cover the time required to design the container or container modification, to review and accept the design, to approve the container, to establish contracts for container fabrication, and fabricate the first container. During this phase, the shipyards and prototype sites where the containers would be stored would also construct or modify the container storage location as appropriate for the alternative chosen. For immobile dry storage containers, this phase would take about 5 years, if 2 years are required to design and accept the container design, 1 year is needed for approval of the container, and 2 years are required to build the container. For containers designed for both storage and shipping, this process would take about 5 years, based on 1 year to design the modifications, 1 year to approve the container, and 3 years to build the container.

The second phase would involve establishing funding. This will take approximately 3 years to complete. The third phase of the implementation period would involve fabrication of the remaining required containers. The estimate of the number of containers is based on the projected schedule for naval vessel refuelings and current estimates of the amount of spent nuclear fuel that would be placed into the containers. Although production rates for immobile dry storage containers and shipping containers are unknown, they can be approximated from existing production rates for M-140 shipping containers. With current manufacturing capabilities, 3 years are required to build an M-140 container, and the manufacturing capacity is about six containers per year. This production rate would need to be accelerated to 18 to 24 containers per year by increasing the number of manufacturers and by making fabrication process improvements. If the production rate of immobile dry storage containers and shipping containers is the same as that of M-140 containers and production rates can be increased as noted above, the supply of immobile dry storage or shipping containers would meet the demand for these containers at some point after the first several years. During the transition period, when an insufficient number of containers would be available to store all the spent fuel planned to be removed from U.S. Navy nuclear-powered vessels, some other means of storing naval spent nuclear fuel would be needed. As described in Section 3.8 of this EIS, it is expected that a transition period of 3 years of shipping followed by 3 years of allowing naval spent nuclear fuel to be stored in shipping containers at shipyards would provide the necessary storage space.

D.1.7.2 Water Pool Storage. If 6 to 9 years would be required to design, approve, and construct

a water pool facility and this process would be initiated for each location within a year after the Record of Decision, water pools would be available for storage of naval spent nuclear fuel about 7 to 10 years following the Record of Decision. During the transition period, when water pools would be under construction at selected locations, some other means of spent nuclear fuel storage would be needed, such as the method described in Section 3.8.

D.1.8 Summary

Table D-6 summarizes the major advantages and disadvantages of the spent nuclear fuel storage alternatives previously discussed in this attachment.

Table D-6. Comparison of naval spent nuclear fuel storage alternatives.

Storage Mode	Advantages	Disadvantages
1. Shipping Container		
A. Storage on Railcars	1. Least amount of container handling after arrival at storage location. 2. Eliminates the need to remove spent fuel modules from the transfer container upon arrival at the storage site.	1. Railcars must be refurbished or replaced after prolonged storage. 2. Requires the largest land area of the storage options, except for Kesselring. 3. Shipping containers are more expensive than immobile dry storage containers and water pools (water pools cost more when small fuel quantities are stored such as at Kesselring).
B. Storage on Concrete Pads	1. Eliminates the need to remove spent fuel modules from the transfer container upon arrival at the storage site. 2. Concrete pads are less expensive than railcar storage if railcars must be replaced or refurbished.	1. More container handling required compared to railcar storage option (if containers will not need to be removed from railcar). 2. Higher total cost than immobile dry storage containers and water pools* (*when large quantities of fuel are stored).

Table D-6 (Cont).

Storage Mode	Advantages	Disadvantages
2. Immobile Dry Storage Containers	1. Lowest total costs of all the storage options.	1. The maximum fuel loading concept requires that the containers be filled with

		water for cooling purposes for several years after removal from the reactor. This requires additional maintenance and slightly increases risk of low-level contamination spillage during accidents. 2. Must remove spent fuel from transfer container and load it into immobile container.
3. Water Pool Storage	1. Has a lower total cost than shipping containers, except for Pearl Harbor and Kesselring which have less containers. 2. Provides opportunity for conducting visual examinations.	1. Has the highest operating costs of all the storage options. 2. Must remove spent fuel from transfer container and load into water pool.

D.2 INSPECT HIGH PRIORITY FUEL AT PUGET SOUND NAVAL SHIPYARD

D.2.1 Introduction

This section of the attachment discusses the alternative of inspecting a limited amount of naval spent nuclear fuel at Puget Sound Naval Shipyard (hereafter referred to as Puget Sound) to provide information on nuclear fuel performance for use in the development of advanced nuclear reactors. The inspections would be performed at the shipyard's existing Water Pit Facility. The limited amount of fuel inspected would be stored at Puget Sound following inspection, and all other spent fuel would be stored in a facility at or near the refueling or defueling sites until the time that permanent geologic storage becomes available.

D.2.2 Water Pit Facility Description

The Water Pit Facility is located at the west side of Dry Dock 5, within the industrial zone of Puget Sound. This zone consists of facilities involved in ship construction and repair, dry docking, and conversions. The area is bounded by Decatur Avenue on the north, the waterfront on the south, the Naval Supply Center on the west, and the main gate on the east. The Water Pit Facility is located approximately 411 meters (1350 feet) from the nearest shipyard public property boundary. Figure D-8 illustrates the layout of the Water Pit Facility.

The Water Pit Facility was originally constructed to provide the shipyard with the capability to refuel nuclear-powered aircraft carriers, with the work for the first such refueling at Puget Sound expected to commence in approximately 2006. To date, the facility water pool has been used for refueling equipment demonstrations and testing.

Figure D-8. Puget Sound Naval Shipyard Water Pit Facility. The following key features of the Water Pit Facility are presented in terms of the facility's original aircraft-carrier refueling mission. Because of these design features, the facility is also considered suitable for limited naval spent fuel inspection operations.

1. A water pool for disassembly, assembly, and holding of fuel cells. The layout of the water pool is described below.
2. A work area for unpackaging, inspection, and preparation of new fuel clusters and associated equipment
3. An area for loading of shipping containers
4. A general use work area to support miscellaneous refueling support operations.

The Water Pit Facility is divided into two distinctive structures. The high bay structure is a radiologically controlled area containing the water pool and general work areas discussed above. This structure is designed to withstand the effects of design basis natural phenomena and of postulated failures of adjoining or adjacent structures without damage to the water pool or components in the water pool. The high bay walls are constructed of concrete to a height of 3.7 meters (12 feet) above ground level. The second structure is the Personnel Support Building which houses offices and other support areas. This structure is designed to meet the requirements of established naval facilities standardized criteria for structural design.

The water pool measures 7.3 meters (24 feet) wide x 20.4 meters (67 feet) long x 11.1 meters (36.5 feet) deep with a water depth of 10.5 meters (34.5 feet). It includes four work areas on each side of the pool at the east end to support refueling operations and a fuel holding area at the west end of the pool. Three of the four work areas are a nominal 2.1 meters (7 feet) x 2.1 meters (7 feet) and the fourth area is a nominal 2.6 meters (8.5 feet) x 2.1 meters (7 feet). The transfer aisle down the center of the pool is provided for all fuel and non-fuel movements. The water pool design includes provisions for isolation gates for each work area, for the fuel holding area, and for the dry pit. This isolation gate arrangement provides the capability to separate the various areas of the water pool if required. The dry pit, measuring 7.3 meters (24 feet) wide x 4.9 meters (16 feet) long x 11.1 meters (36.5 feet) deep, permits expansion of the water pool as needed.

D.2.3 Limited Inspection Operations

If future naval spent fuel examinations could not be accomplished at current capacity, the capacity which was available would be used to best advantage. Only naval spent nuclear fuel identified as having the greatest scientific value would be selected for detailed examination. Generally, this is spent nuclear fuel which is the first of a kind design or which has a characteristic of special interest.

Naval nuclear-powered ships would continue to be refueled and defueled at various shipyards across the country. Most of the spent fuel would be stored in a facility at or near the refueling and defueling sites until the time that permanent geologic storage becomes available. Those few fuel cells identified as high priority would be transported by railcar to Puget Sound in standard shielded shipping containers. Following its receipt in the Water Pit Facility's railcar work area, a shipping container would be prepared for fuel cell removal (dust cover removed, leveled, filled with water, containment installed, access plug removed). The fuel cells would be removed from the shipping container, one at a time, and transferred to the water pool in a shielded transfer container. The cells would be discharged into the pool and placed in the holding racks to await examination work. Upon completion of examination work, the spent fuel would be stored at Puget Sound as described in Section D.1. Storage facilities would have to be designed and certified to accommodate module sections resulting from spent fuel examinations as well as intact modules.

The following major items of water pool equipment (or equivalent) are considered necessary to support a high-priority naval spent nuclear fuel examination program. Also necessary are the relatively small and portable cameras and light sources for visual inspections. This equipment would support those spent fuel examinations currently performed in the ECF water pools at INEL as described in Section B.4.1 of Attachment B and summarized below.

EQUIPMENT ITEM	PURPOSE	FLOOR SPACE REQUIRED
Bandsaw/	Remove non-fuel structurals above & below fuel region	46.4 m2 (500 ft2)
Upender	to provide access for inspection and to rotate cells between vertical and horizontal orientations	8.2 m x 5.6 m (27 ft x 18.5 ft)
Universal	Measure fuel cell dimensions	7.5 m2 (81 ft2)

Inspection Station		2.7 m x 2.7 m (9 ft x 9 ft)
Vertical Inspection Gage	Trace contour of surfaces of fuel cell assemblies and control rods	16.7 m2 (180 ft2) 3.0 m x 5.5 m (10 ft x 18 ft)
Milling Machine	Section fuel cells into subassemblies, preassemblies, and elements for other examinations	11.1 m2 (120 ft2) 3.7 m x 3.0 m (12 ft x 10 ft)

Based on floor space requirements, the Water Pit Facility water pool and dry pit could not accommodate spent nuclear fuel examinations without removal of work area partition walls and without removal of the aircraft carrier refueling equipment. As a result, Puget Sound would no longer have the capability to refuel nuclear-powered aircraft carriers. Expansion of the Water Pit Facility to accommodate simultaneous refueling and examination operations is undesirable due to the proximity of other shipyard facilities.

Puget Sound does not have a shielded cell examination capability. Two options were considered for implementing such a capability:

1. Transfer fuel sections from Puget Sound to a shielded cell facility at another Naval Reactors site such as the Knolls Atomic Power Laboratory near Schenectady, New York, or the Bettis Atomic Power Laboratory near Pittsburgh, Pennsylvania. This would require additional shipments of spent fuel sections across the country. The spent fuel would be transported in shipping casks which would have to be certified for this purpose.
2. Construct shielded cells at Puget Sound. These cells would necessarily be sited some distance from the Water Pit Facility since sufficient space is not available either within the facility or adjacent to it in the industrial zone of the shipyard. In addition, a means of transferring items for examination between the water pool and the shielded cells would have to be implemented. Shielded cask movements via truck and cart movements via underground tunnel are two possible means of transfer. This option is undesirable because it involves construction of a new facility but does not provide direct communication between the water pool and shielded cells.

Based on the above discussion, the alternative of examining a limited amount of naval spent nuclear fuel would include a full range of water pool visual and dimensional inspections at the Puget Sound Water Pit Facility and a full range of shielded cell examinations at another Naval Reactors site. This alternative would therefore include all INEL-ECF capabilities as described in Sections B.4.1 and B.4.3 of Attachment B.

D.2.4 Advantages and Disadvantages of this Alternative

Advantages

1. Portions of the naval spent nuclear fuel examination program could be moved from INEL-ECF without having to construct new facilities. A full range of water pool inspections could be accomplished at Puget Sound. A full range of shielded cell examinations could be accomplished at another Naval Reactors site.

Disadvantages

1. The small size of the water pool complicates placement of inspection equipment. As a result, the equipment would be limited in nature and would require removal of water pool work area partition walls and removal of aircraft carrier refueling equipment. As a result, Puget Sound would no longer have the capability to refuel nuclear-powered aircraft carriers.
2. Transferring items for examination between the water pool and shielded cells would involve additional spent fuel shipments across the country and would require design and certification of a container for this purpose.

D.2.5 Facility Support Systems

The systems which were intended to support the aircraft carrier refuelings will also support the limited naval spent fuel inspection efforts. These include the water pool fluid systems, the heating and ventilation systems, and the normal and emergency electrical power systems.

D.2.6 Radiation Sources

The primary sources of radiation in the Water Pit Facility would be the spent fuel and the associated irradiated components which are handled during inspection operations. Radiation results from the fission products which reside in the fuel region of the depleted clusters and are contained by the fuel cladding. The cladding around the fuel region would not be penetrated by any fuel cell cutting or sectioning operation in the Water Pit Facility. Irradiated non-fuel components are also sources of radiation, as are corrosion products which reside on all external surfaces. Handling operations could cause some of the corrosion products to become detached from the surfaces. Therefore, in addition to direct radiation, contamination must be considered in the control of radiation sources.

The water pool water is treated by the filtration and purification system to maintain the waterborne radioactivity as low as reasonably achievable, typically less than 1 x 10-6 microcurie Co-60/ml. This level of activity is below the concentration limit in 10CFR20, Attachment B, Table 2 for liquid effluents released to the general environment. The vessels and piping in the filter system then become potential radiation sources. The water must be considered a source even though its radiation level will be very low. The waterborne radioactive material causes equipment in the pools to become radiation sources, the water pool floor to become contaminated, and a radioactive scum ring to form on the walls of the water pool at the water surface. Even considering all of these sources contributing to the ambient radiation level in the water pool area, the controls which are exercised will ensure that the overall source is minimal and the occupational exposure remains as low as reasonably achievable.

There would normally be no airborne radioactivity generated by the handling of the cells in the water pool. However, very low levels of airborne activity (approximately 1 x 10-12 microcurie Co-60/ml) have been detected near the surfaces of other water pools. This level of activity is below the concentration limit in 10CFR20, Attachment B, Table 2 for airborne effluents released to the general environment. The presence of even low-level airborne contamination will eventually lead to the ventilation system ductwork and HEPA filters becoming sources of radiation. This would occur over a very long period of time and the radiation levels would be controlled to a very low level. As noted above, the controls which are exercised will ensure that the occupational exposure remains as low as reasonably achievable.

D.2.7 Radiological Protection Features

The facility is designed to protect workers and the general public from radiological risk. Controls are such that workers receive much less than the allowable limits for radiation and radioactivity. The ventilation system is designed to mitigate the consequences of an accidental release of radionuclides within the Water Pit Facility building and to limit the atmospheric release at the stack. The double-walled (reinforced concrete, stainless steel liner) water pool is designed to prevent leakage under design earthquake force loading conditions. The radioactive fluid systems will maintain zero liquid discharge to the environment during Water Pit Facility operations.

D.2.8 Estimated On-Site Dose Assessment

The occupational radiation exposure for workers performing limited spent fuel inspections in the Water Pit Facility is expected to be consistent with that of ECF workers performing similar operations at INEL. As discussed in Section 5.2.12.1, radiation exposures to ECF workers at INEL have averaged approximately 100 mrem per year. The person-rem per year for the Water Pit Facility will vary with the manning level which is dependent on the spent fuel inspection activity occurring in the facility. However, the maximum manning level is anticipated not to exceed 60 people.

D.2.9 Seismic Design

Structural loadings due to seismic activity were determined as follows. Building floor response spectra for the horizontal and vertical directions were obtained from a three-dimensional damping mass spring model of the high bay which included soil-structure interaction, subjected to a 0.35 g ground acceleration value resulting from the seismic design analysis. The high bay superstructure and substructure were analyzed using the floor response spectra in separate finite element computer models. The superstructure model was subjected to structural loads which included a 113.5-metric ton (125-ton) load lifted by the large overhead crane. The combined forces of these loads with the seismic loads were applied to the substructure model at the column base plate locations. The substructure model was subjected to the design earthquake response spectra. This method was repeated for other combinations of structural loads with wind or tornado loads. Members were checked and designed for the maximum stress from any of the loading combinations. In addition, the water pool is designed to contain the pool water under design earthquake force loading conditions.

ATTACHMENT E - DESCRIPTION OF RECEIPT, HANDLING, AND EXAMINATION OF

NAVAL SPENT NUCLEAR FUEL AT ALTERNATE DOE FACILITIES

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ATTACHMENT E

DESCRIPTION OF RECEIPT,
HANDLING, AND EXAMINATION OF NAVAL SPENT
NUCLEAR FUEL AT ALTERNATE DOE FACILITIES

E.1 DISCUSSION

This attachment describes the options for establishing new or modified facilities that essentially duplicate the capabilities of the existing Expended Core Facility (ECF) at the Idaho National Engineering Laboratory (INEL). Also discussed herein are the differences from the existing facility, which is described in detail in Attachment B.

The capabilities of the ECF at INEL include detailed examinations of spent nuclear fuel from naval reactors and test specimens from the Advanced Test Reactor (ATR) at the INEL Test Reactor Area. It would be possible to provide ECF capabilities at an alternate DOE facility (Savannah

River Site, Hanford Site, Oak Ridge Reservation, or Nevada Test Site) by constructing an entirely new facility. At Savannah River or Hanford, ECF capabilities could also be provided by modifying an existing facility. The preferred locations for siting an ECF at Savannah River, Hanford, Oak Ridge, and the Nevada Test Site are described in Sections 4.3.1, 4.4.1, 4.5.1, and 4.6.1, respectively. The main advantage of new construction is that the facility can provide all capabilities currently available at the ECF at INEL without limitations. The new construction water pool and shielded cell complex would be constructed in such a manner as to duplicate, as much as possible, the capabilities of the ECF at INEL. The existing ECF is highly capable, having been designed to accomplish the tasks required by the Naval Nuclear Propulsion Program. Key disadvantages of new construction, however, are high cost and the time necessary to initiate and complete construction.

Modification of an existing facility at Savannah River or Hanford which has at least some of the features that are required in a functional ECF would enable reductions in cost and time to achieve full capability, depending on how many facility modifications are required. A disadvantage, however, is that some of the methods currently in use at the ECF at INEL may also require modification to effectively and promptly utilize an existing facility, and such modifications may compromise the capabilities of the examination facility. The existing facility that can be made a part of the Savannah River Site is the Barnwell Nuclear Fuel Plant (hereafter referred to as the Barnwell Plant) which is unused and available following acquisition from its present private corporate owners. The existing facility on the Hanford Site is the Fuels and Materials Examination Facility (FMEF) which is unused and available immediately. Sections E.2 and E.3 describe the modifications to existing facilities or to current processes that would be needed to provide the complete range of ECF capabilities at the Barnwell Plant and the FMEF. Section E.4 provides a discussion of how naval spent fuel and test specimen examination work would proceed through the interim period as this work is being transferred from the ECF at INEL to the ECF location at the alternate DOE facility.

Receipt and handling of naval spent fuel at the new ECF location at the alternate DOE facility would be similar to receipt and handling of spent fuel at the ECF at INEL as described in Section B.2 of Attachment B. Following all examinations at the new ECF, most of the spent fuel would be loaded in the water pool into shipping casks for transport to the long-term fuel storage location at the same DOE facility. The spent fuel would remain at this location until the time that ultimate disposition is possible.

The new ECF would also duplicate the capabilities of the ECF at INEL with respect to the assembly, disassembly, and examination of ATR irradiation test specimens.

E.2 USE OF THE BARNWELL PLANT AT SAVANNAH RIVER

FOR ECF WORK

The Barnwell Plant is not owned by DOE but could be acquired and incorporated into the Savannah River Site property. It has a water pool complex with about 433 square meters (4660 square feet) of surface area (see Figure E-1) that can be utilized with minor modifications to perform unloading of naval fuel transport casks in a manner virtually identical to that employed at the ECF at INEL. An overhead crane running the length of the water pool would have to be added. However, providing naval spent nuclear fuel and test specimen examination capabilities comparable to the ECF at INEL would entail an expansion of the Barnwell Plant water pool to at least two times its present size. The design of the Barnwell Plant facility provides for such an expansion in an easterly direction while the existing water pool remains functional in a reduced capacity mode.

Figure E-1. Plan view of the Barnwell Plant Fuel Receiving and Storage Station. It is envisioned that the full ECF shielded cell capabilities could be provided at the Barnwell Plant using a combination of the three remote maintenance cells and the eight sample and analytical cells. Material would be transferred from the water pool to the remote maintenance cells via a conveyor. The crane equipment maintenance gallery and the upper level of the remote process cell are connected by a shielded door; these cells are connected to the remote maintenance and scrap cell below by hatches (see Figure E-2). Additional work stations (viewing window and manipulator ports) would have to be added to service these cells. The remote maintenance cells are connected to the sample and analytical cells above via a waste chute which would have to be upgraded to improve transfer capability between these cell areas. Methods would have to be developed for material movement from one shielded cell elevation to another. The combined length of the ECF shielded cells at INEL is less than 57.9 meters (190 feet). The combined length of the Barnwell Plant remote maintenance cells and sample and analytical cells is greater than 67.1 meters (220 feet), so that sufficient cell work space should be available. There are also five contact maintenance cells available, although at present they have no workstations and are not connected to each other, to any other cell area, or to the water pool. An alternative to the Barnwell Plant water pool expansion would be to use the contact maintenance cells for some of the operations presently performed in the ECF water pool at INEL. Varying amounts of existing equipment and piping in the Barnwell Plant shielded cells would have to be removed and disposed.

Once modified, the Barnwell Plant would provide the full range of water pool and shielded cell examination capabilities. However, the arrangement of the cells in the fuel handling area could make material movement within the facility more difficult than material movement at the ECF at INEL. As a result, throughput in the Barnwell Plant could be adversely affected.

E.3 USE OF THE FUELS AND MATERIALS EXAMINATION FACILITY

AT HANFORD FOR ECF WORK

The FMEF on the DOE Hanford Site in Washington currently has a large shielded cell complex that is suitable for ECF-type shielded cell operations with several modifications. Those modifications primarily entail the logistics associated with installing the equipment in the cells and transporting items for examination to and from this equipment.

Figure E-2. Elevation looking north in the Barnwell Plant fuel handling area.

At present, there is no water pool at FMEF. One means of providing this portion of ECF capabilities would be to establish a dry cell facility. The FMEF main process cell, decontamination cell, and upper process cell were evaluated for such a facility (see Figure E-3). Conceptually, material would be transferred from shielded casks in the shipping and receiving crane bay into the decontamination cell via a ceiling port. At present, there are only small penetrations between the decontamination cell and main process cell; this would have to be upgraded to facilitate material transfer. The combined surface area of the three cells is about 706 square meters (7600 square feet), compared to at least 866 square meters (9320 square feet) for the conceptual expanded Barnwell Plant water pool discussed previously. This suggests that the full ECF water pool capabilities could not be provided in the dry cell facility. In addition, one or more of the process cells is intended for inclusion in the shielded cell complex (see next paragraph). Removal of decay heat from spent fuel and irradiation test specimens in temporary dry storage would have to be evaluated. It is concluded that duplication of ECF spent fuel and test specimen examination capabilities at FMEF would require construction of a new water pool at least two times the present size of the Barnwell Plant water pool. The location of the pool and the means for transferring items between the pool and the shielded cell complex would have to be evaluated.

It is envisioned that the full ECF shielded cell capabilities could be provided at FMEF using a combination of the main process cell and the 14 process support cells. The main process cell is connected to the process support cells below by hatches (see Figure E-3). There appear to be sufficient workstations (viewing window and manipulator ports) servicing all cells. Methods would have to be developed for material movement from one shielded cell elevation to the other. The combined length of the FMEF main process cell and process support cells is greater than 76.2 meters (250 feet), so that sufficient cell work space should be available. The decontamination cell and upper process cell would be available in support of shielded cell operations. The FMEF shielded cells are essentially empty.

Once modified, the FMEF would provide the full range of water pool and shielded cell examination capabilities. However, the arrangement of the cells in the fuel handling area and the separation of the water pool and shielded cells would make material movement within the facility more difficult than material movement at the ECF at INEL. As a result, throughput in the FMEF could be adversely affected.

E.4 INTERIM OPERATIONAL PERIOD

Figure E-3. FMEF fuel handling area.

A transitional period will exist between the date that the Record of Decision is issued and the date that the alternative selected can be fully implemented (unless the selected alternative maintains ECF operations at INEL). This transition period would be approximately 6 years. If it is desired that all ECF work be completely transferred to an alternate DOE facility, then actions would have to be taken to minimize the disruption in examination capability for naval spent nuclear fuel and ATR test specimens. This section discusses how this will be accomplished if the alternate DOE facility option is selected in the Record of Decision.

The Barnwell Plant would have to be acquired by the DOE from its present private corporate owners. It is estimated that less than $800 million in acquisition, modification, and construction costs would complete the Barnwell Plant for ECF usage.

The FMEF at Hanford is already owned by the DOE but it appears to require a greater amount of design effort to be a fully functional ECF since a large water pool would need to be constructed and tied in to the shielded cell complex in order to initiate fuel receipt. It is estimated that less than $800 million in modification and construction costs would complete the FMEF for ECF usage.

During the transitional period between the Record of Decision and full implementation of the selected alternative, shipments of naval spent nuclear fuel to the ECF at INEL would continue, pending construction of storage and examination facilities at the new site. All naval spent nuclear fuel would then be transferred to the new site.

ATTACHMENT F - ANALYSIS OF NORMAL OPERATIONS AND ACCIDENT

CONDITIONS

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ATTACHMENT F

ANALYSIS OF NORMAL OPERATIONS AND ACCIDENT CONDITIONS

This attachment presents estimated environmental consequences, event probabilities, and risk (a product of probability and consequence) for both normal operations and postulated accident scenarios related to the storage and examination of naval spent nuclear fuel. Normal operations and accidents are evaluated to estimate the potential for releases of both radioactive material and toxic chemicals. The results of these analyses are presented in terms of the health effects to facility workers and the public predicted due to the release of radioactive materials and toxic chemicals into the environment. Effects on environmental factors are also presented, based on the amount of land which could be impacted due to postulated accidents.

Analysis results are presented for several different Department of Energy (DOE) and naval shipyard locations which are being considered as alternative sites for future naval spent nuclear fuel storage and examination. The DOE facilities evaluated include the Idaho National Engineering Laboratory (INEL), Savannah River Site, Hanford Site, Nevada Test Site, Oak Ridge Reservation (hereafter referred to as Oak Ridge), and Kenneth A. Kesselring Site. Puget Sound Naval Shipyard, Pearl Harbor Naval Shipyard, Norfolk Naval Shipyard, and Portsmouth Naval Shipyard have also been evaluated for naval spent nuclear fuel operations.

SUMMARY

Analyses of normal operations and design basis and beyond design basis hypothetical accidents were performed to estimate the potential consequences due to release of radioactive materials and toxic chemicals. The analysis results for radiological operations have been summarized by the locations and alternatives being considered in the Environmental Impact Statement.

Historical Accidents

The Naval Nuclear Propulsion Program has an outstanding nuclear safety record. In over 4500 reactor-years of operation and more than 300 refuelings and defuelings of Naval reactors, there has never been a nuclear reactor accident, criticality accident, transportation accident, or any release of radioactivity having a significant effect on the environment.

Summary of Naval Spent Nuclear Fuel (SNF) Alternatives

Alternative	Description of SNF Activity
No Action	SNF retained at shipyards and Kesselring. Dry storage in containers only.
Decentralization No Examination	SNF retained at shipyards and Kesselring. Either dry containers or water pool storage would be used.
Decentralization Limited Examination	SNF retained at shipyards and Kesselring. Either dry containers or water pool storage would be used. Limited SNF shipments to Puget Sound Naval Shipyard for examination.
Decentralization Full Examination	All SNF shipped to INEL-ECF for examination. All SNF returned to origin for storage in either dry containers or water pools.
Planning Basis	SNF would be received, examined, and stored at INEL as in past years. The proposed dry cell facility would be completed at ECF.
Regionalization or Centralization	SNF would be received, examined, and stored at either INEL, Hanford, Savannah River, Nevada Test Site, or Oak Ridge.

Normal Operations

Table F-1 presents the estimated number of fatal cancers per year to the general population living within a 50-mile radius of each facility due to radiological releases from normal operations. The results in this table were calculated using the methods described in Section F.1.3. The number of fatal cancers is very low at all locations and for all alternatives.

The ISC2 computer code (EPA 1992b) was used to estimate the concentration of chemicals released during normal operations. The results show that for INEL, Hanford, Savannah River, the

Nevada Test Site, the Barnwell Plant, and Oak Ridge, no ambient air quality standards would be exceeded; therefore, no adverse effects are expected. Heating boilers and emergency diesel generators already exist at the Navy shipyard locations and thus selection of these alternate locations would not result in a measurable increase in emissions.

Hypothetical Accident Evaluations

Several hypothetical accidents were analyzed at each facility for each of the alternatives. The results are summarized in Tables F-2 and F-3. The results in these tables were calculated using the methods described in Section F.1.3. Both fatal cancers from the maximum foreseeable accident at each location and the most severe risk from a facility accident at each location are presented. Risk is defined as the product of the consequences of an event multiplied by the probability of that event. The risks associated with the accidents analyzed have not been added together in order to avoid creating the impression that all risks have been calculated. The risks presented in this appendix cover the complete range of accidents which might make a detectable contribution to overall risk and additional analyses would not be expected to result in increases in calculated risk. The facility accident which results in the highest risk is a drained water pool at INEL, Hanford, Puget Sound, Portsmouth, and Kesselring. For Savannah River, Pearl Harbor, Norfolk, the Nevada Test Site, and Oak Ridge, an airplane crash into a dry storage area or a dry cell facility results in the greatest risk. As was the case for the normal operations evaluation, the accident risk is very low at all locations and for all alternatives.

Table F-4 presents a summary of the risk of fatal cancers by alternative for normal operations and most severe facility accident for each alternative. Consistent with the detailed tables, this summary table shows that all alternatives and all locations associated with spent fuel examination have very low risk.

Tables F-5 through F-8 present a summary by alternative of the impacts from all naval spent nuclear fuel facility radiological accidents which were analyzed.

A shipping accident in Puget Sound, at a location in the shipping lane approximately 2 miles from Seattle, was also analyzed using the methods described in this Attachment. This hypothetical accident results in a fire onboard the ship which involves spent nuclear fuel shipping containers. When compared to the facility accidents analyzed at Puget Sound Naval Shipyard, this shipping accident has a slightly lower risk of fatal cancers than the most severe facility accident at the shipyard.

The EPI computer code (Homann 1988) was used to estimate the concentration of chemicals released in the event of two postulated accident conditions. One postulated accident involved a chemical spill and fire at ECF and the alternate DOE sites and the other postulated accident involved a diesel fuel fire at ECF, the alternate DOE sites, and the shipyard locations. The chemical

Table F-1. Number of fatal cancers per year from normal operations (fatalities per year to general population located within 50-mile radius of site).

DRY STORAGE AT NAVAL NUCLEAR PROPULSION PROGRAM SITES, WATER POOL STORAGE AT DOE SITES

	No Action	Decentralization-No Examination	Decentralization-Puget Sound Exam	Decentralization-INEL Exam	Planning Basis/ Regionalization/ Centralization-INEL	Regionalization/ Centralization-Hanford	Regionalization/ Centralization-Savannah River	Regionalization/ Centralization-Nevada Test Site	Regionalization/ Centralization-Oak Ridge
INEL	0.00	0.00	0.00	8.50 x 10-7	8.50 x 10-7	0.00	0.00	0.00	0.00

Hanford	0.00	0.00	0.00	0.00	0.00	4.00 x 10-6	0.00	0.00	0.00
Savannah River	0.00	0.00	0.00	0.00	0.00	0.00	1.80 x 10-5	0.00	0.00
Nevada Test Site	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00 x 10-8	0.00
Oak Ridge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00 x 10-5
Puget Sound	1.20 x 10-6	1.20 x 10-6	6.62 x 10-5**	1.20 x 10-6	0.00	0.00	0.00	0.00	0.00
Pearl Harbor	9.30 x 10-9	9.30 x 10-9	9.30 x 10-9	9.30 x 10-9	0.00	0.00	0.00	0.00	0.00
Portsmouth	2.30 x 10-7	2.30 x 10-7	2.30 x 10-7	2.30 x 10-7	0.00	0.00	0.00	0.00	0.00
Norfolk	2.10 x 10-5	2.10 x 10-5	2.10 x 10-5	2.10 x 10-5	0.00	0.00	0.00	0.00	0.00
Kesselring	4.10 x 10-12	4.10 x 10-12	4.10 x 10-12	4.10 x 10-12	0.00	0.00	0.00	0.00	0.00
Total	2.24 x 10-5	2.24 x 10-5	8.74 x 10-5	2.33 x 10-5	8.50 x 10-7	4.00 x 10-6	1.80 x 10-5	9.00 x 10-8	5.00 x 10-5
WATER POOL STORAGE AT ALL SITES*									
INEL	0.00	0.00	0.00	8.50 x 10-7	8.50 x 10-7	0.00	0.00	0.00	0.00
Hanford	0.00	0.00	0.00	0.00	0.00	4.00 x 10-6	0.00	0.00	0.00
Savannah River	0.00	0.00	0.00	0.00	0.00	0.00	1.80 x 10-5	0.00	0.00
Nevada Test Site	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00 x 10-8	0.00
Oak Ridge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.0 x 10-5
Puget Sound	1.20 x 10-6	6.50 x 10-5	6.50 x 10-5	6.50 x 10-5	0.00	0.00	0.00	0.00	0.00
Pearl Harbor	9.30 x 10-9	7.00 x 10-5	7.00 x 10-5	7.00 x 10-5	0.00	0.00	0.00	0.00	0.00
Portsmouth	2.30 x 10-7	2.30 x 10-5	2.30 x 10-5	2.30 x 10-5	0.00	0.00	0.00	0.00	0.00
Norfolk	2.10 x 10-5	1.40 x 10-4	1.40 x 10-4	1.40 x 10-4	0.00	0.00	0.00	0.00	0.00
Kesselring	4.10 x 10-12	4.10 x 10-5	4.10 x 10-5	4.10 x 10-5	0.00	0.00	0.00	0.00	0.00
Total	2.24 x 10-5	3.39 x 10-4	3.39 x 10-4	3.40 x 10-4	8.50 x 10-7	4.00 x 10-6	1.80 x 10-5	9.00 x 10-8	5.00 x 10-5

*Under No Action alternative, dry storage at Naval Nuclear Propulsion Program sites

**Includes dry storage and water pool examination under this alternative

Table F-2. Number of fatal cancers from a maximum foreseeable accident (fatalities per accident over a 50-year period to general population within a 50-mile radius of site).

DRY STORAGE AT NAVAL NUCLEAR PROPULSION PROGRAM SITES, WATER POOL STORAGE AT DOE SITES

	No Action	Decentralization-No Examination	Decentralization-Puget Sound Exam	Decentralization-INEL Exam	Planning Basis/ Regionalization/ Centralization-INEL	Regionalization-Hanford	Regionalization/ Centralization-Savannah River	Re-gionalization/ Cen-trali-	Re-gionalization/ Cen-trali-

								zation-Nevada Test Site	zation-Oak Ridge
INEL	0.00	0.00	0.00	1.70 x 10-2	1.70 x 10-2	0.00	0.00	0.00	0.00
Hanford	0.00	0.00	0.00	0.00	0.00	4.70 x 10-2	0.00	0.00	0.00
Savannah River	0.00	0.00	0.00	0.00	0.00	0.00	4.80	0.00	0.00
Nevada Test Site	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.80 x 10-1	0.00
Oak Ridge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.40
Puget Sound	1.7 x 10-2	1.7 x 10-2	5.1 x 10-1**	1.7 x 10-2	0.00	0.00	0.00	0.00	0.00
Pearl Harbor	2.60 x 101	2.60 x 101	2.60 x 101	2.60 x 101	0.00	0.00	0.00	0.00	0.00
Portsmouth	9.00	9.00	9.00	9.00	0.00	0.00	0.00	0.00	0.00
Norfolk	1.6 x 101	1.6 x 101	1.6 x 101	1.6 x 101	0.00	0.00	0.00	0.00	0.00
Kesselring	7.50	7.50	7.50	7.50	0.00	0.00	0.00	0.00	0.00
Max	2.60 x 101	2.60 x 101	2.60 x 101	2.60 x 101	1.70 x 10-2	4.70 x 10-2	4.80	1.80 x 10-1	8.40
WATER POOL STORAGE AT ALL SITES*									
INEL	0.00	0.00	0.00	1.70 x 10-2	1.70 x 10-2	0.00	0.00	0.00	0.00
Hanford	0.00	0.00	0.00	0.00	0.00	4.70 x 10-2	0.00	0.00	0.00
Savannah River	0.00	0.00	0.00	0.00	0.00	0.00	4.80	0.00	0.00
Nevada Test Site	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.80 x 10-1	0.00
Oak Ridge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.40
Puget Sound	1.7 x 10-2	5.1 x 10-1	5.1 x 10-1	5.1 x 10-1	0.00	0.00	0.00	0.00	0.00
Pearl Harbor	2.60 x 101	1.10	1.10	1.10	0.00	0.00	0.00	0.00	0.00
Portsmouth	9.00	3.40 x 10-1	3.40 x 10-1	3.40 x 10-1	0.00	0.00	0.00	0.00	0.00
Norfolk	1.6 x 101	6.0 x 10-1	6.0 x 10-1	6.0 x 10-1	0.00	0.00	0.00	0.00	0.00
Kesselring	7.50	2.50 x 10-1	2.50 x 10-1	2.50 x 10-1	0.00	0.00	0.00	0.00	0.00
Max	2.60 x 101	1.10	1.10	1.10	1.70 x 10-2	4.70 x 10-2	4.80	1.80 x 10-1	8.40

*Under No Action alternative, dry storage at Naval Nuclear Propulsion Program sites

**Includes dry storage and water pool examination under this alternative

Table F-3. Most severe risk from a facility accident (probability of fatalities per year per accident to general population within a 50-mile radius of site).

DRY STORAGE AT NAVAL NUCLEAR PROPULSION PROGRAM SITES, WATER POOL STORAGE AT DOE SITES

	No Action	Decentralization-No Examination	Decentralization-Puget Sound Exam	Decentralization-INEL Exam	Planning Basis/Regionalization-Centralization-INEL	Regionalization/Centralization-Hanford	Regionalization/Centralization-Savannah River	Regionalization/Centralization-Nevada Test Site	Regionalization/Centralization-Oak Ridge
INEL	0.00	0.00	0.00	1.70×10^{-7}	1.70×10^{-7}	0.00	0.00	0.00	0.00
Hanford	0.00	0.00	0.00	0.00	0.00	4.70×10^{-7}	0.00	0.00	0.00
Savannah River	0.00	0.00	0.00	0.00	0.00	0.00	9.60×10^{-6}	0.00	0.00
Nevada Test Site	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.20×10^{-8}	0.00
Oak Ridge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.40×10^{-6}
Puget Sound	1.7×10^{-7}	1.7×10^{-7}	5.10×10^{-6}**	1.7×10^{-7}	0.00	0.00	0.00	0.00	0.00
Pearl Harbor	2.60×10^{-4}	2.60×10^{-4}	2.60×10^{-4}	2.60×10^{-4}	0.00	0.00	0.00	0.00	0.00
Portsmouth	9.00×10^{-7}	9.00×10^{-7}	9.00×10^{-7}	9.00×10^{-7}	0.00	0.00	0.00	0.00	0.00
Norfolk	1.6×10^{-5}	1.6×10^{-5}	1.6×10^{-5}	1.6×10^{-5}	0.00	0.00	0.00	0.00	0.00
Kesselring	7.50×10^{-7}	7.50×10^{-7}	7.50×10^{-7}	7.50×10^{-7}	0.00	0.00	0.00	0.00	0.00
Max	2.60×10^{-4}	2.60×10^{-4}	2.60×10^{-4}	2.60×10^{-4}	1.70×10^{-7}	4.70×10^{-7}	9.60×10^{-6}	7.2×10^{-8}	8.40×10^{-6}
WATER POOL STORAGE AT ALL SITES*									
INEL	0.00	0.00	0.00	1.70×10^{-7}	1.70×10^{-7}	0.00	0.00	0.00	0.00
Hanford	0.00	0.00	0.00	0.00	0.00	4.70×10^{-7}	0.00	0.00	0.00
Savannah River	0.00	0.00	0.00	0.00	0.00	0.00	9.60×10^{-6}	0.00	0.00
Nevada Test Site	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.20×10^{-8}	0.00
Oak Ridge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.40×10^{-6}
Puget Sound	1.7×10^{-7}	5.1×10^{-6}	5.1×10^{-6}	5.1×10^{-6}	0.00	0.00	0.00	0.00	0.00
Pearl Harbor	2.60×10^{-4}	1.10×10^{-5}	1.10×10^{-5}	1.10×10^{-5}	0.00	0.00	0.00	0.00	0.00
Portsmouth	9.00 x	3.40 x	3.40 x	3.40 x	0.00				

	10-7	10-6	10-6	10-6		0.00	0.00	0.00	0.00
Norfolk	1.6 x 10-5	6.0 x 10-6	6.0 x 10-6	6.0 x 10-6	0.00	0.00	0.00	0.00	0.00
Kesselring	7.50 x 10-7	2.50 x 10-6	2.50 x 10-6	2.50 x 10-6	0.00	0.00	0.00	0.00	0.00
Max	2.60 x 10-4	1.10 x 10-5	1.10 x 10-5	1.10 x 10-5	1.70 x 10-7	4.70 x 10-7	9.60 x 10-6	7.20 x 10-8	8.40 x 10-6

*Under No Action alternative, dry storage at Naval Nuclear Propulsion Program sites

**Includes dry storage and water pool examination under this alternative

Table F-4. Risk of fatal cancers by alternative (probability of fatalities per year per accident to general population within a 50-mile radius of site).

	No Action	Decentralization-No Examination	Decentralization-Puget Sound Exam	Decentralization-INEL Exam	Planning Basis/Regionalization Centralization-INEL	Regionalization/Centralization-Hanford	Regionalization/Centralization-Savannah River	Regionalization/Centralization-Nevada Test Site	Regionalization/Centralization-Oak Ridge
Normal Operations Risk Dry Storage At Navy Sites, Water Pool Storage At DOE Sites	2.24 x 10-5	2.24 x 10-5	8.74 x 10-5	2.33 x 10-5	8.50 x 10-7	4.00 x 10-6	1.80 x 10-5	9.00 x 10-8	5.00 x 10-5
Normal Operations Risk Water Pool Storage At All Sites	2.24 x 10-5	3.39 x 10-4	3.39 x 10-4	3.40 x 10-4	8.50 x 10-7	4.00 x 10-6	1.80 x 10-5	9.00 x 10-8	5.00 x 10-5
Most Severe Risk From A Facility Accident Dry Storage At Naval Nuclear Propulsion Program Sites, Water Pool Storage At DOE Sites	2.60 x 10-4 (1)	2.60 x 10-4 (1)	2.60 x 10-4 (1)	2.60 x 10-4 (1)	1.70 x 10-7 (2)	4.70 x 10-7 (2)	9.60 x 10-6 (1)	7.20 x 10-8 (1)	8.40 x 10-6 (1)
Most	2.60 x	1.10 x 10-5	1.10 x 10-5	1.10 x 10-5	1.70 x	4.70 x 10-7			

9.60 x 10-6 7.2 x 10-8 8.40 x
Severe 10-4 (2) (2) (2) 10-7 (2)
(1) (1) 10-6
Risk From (1) (2)
(1)
A Facility
Acci-
dent
Water Pool
Storage At
All Sites

(1) Accident initiator - Airplane crash
(2) Accident initiator - Drained water pool

Table F-5. Impacts from naval spent nuclear fuel facility radiological accidents for the No Action alternative.

Accident Description	Probability (per year)	Consequences to Public (fatalities per accident)	Risk to Public (fatalities)	Dose to Worker (rem)	Dose to MOI (rem)
DRY STORAGE ACCIDENTS					
Mechanical Damage					
Puget Sound	1.0 x 10-5	1.7 x 10-2	1.7 x 10-7	5.6 x 10-2	3.9 x 10-2
Pearl Harbor	1.0 x 10-5	3.0 x 10-2	3.0 x 10-7	5.6 x 10-2	2.1 x 10-2
Norfolk	1.0 x 10-5	1.8 x 10-2	1.8 x 10-7	5.6 x 10-2	8.1 x 10-2
Portsmouth	1.0 x 10-5	1.0 x 10-2	1.0 x 10-7	5.6 x 10-2	4.2 x 10-2
Kesselring	1.0 x 10-5	7.4 x 10-3	7.4 x 10-8	5.6 x 10-2	8.1 x 10-3
Airplane Crash					
Pearl Harbor	1.0 x 10-5	26	2.6 x 10-4	92	19
Norfolk	1.0 x 10-6	16	1.6 x 10-5	92	72
Portsmouth	1.0 x 10-7	9.0	9.0 x 10-7	92	38
Kesselring	1.0 x 10-7	7.5	7.5 x 10-7	92	7.7

Table F-6. Impacts from naval spent nuclear fuel facility radiological accidents for Decentralization alternatives.

Accident Description	Probability (per year)	Consequences to Public (fatalities per accident)	Risk to Public (fatalities)	Dose to Worker (rem)	Dose to MOI (rem)
WET STORAGE AND EXAMINATION ACCIDENTS					
*Information applicable only for full examinations at INEL.					
Drained Water Pool					
*INEL	1.0 x 10-5	1.7 x 10-2	1.7 x 10-7	2.1	1.7 x 10-2
Puget Sound	1.0 x 10-5	5.1 x 10-1	5.1 x 10-6	2.1	1.4
Pearl Harbor	1.0 x 10-5	1.1	1.1 x 10-5	2.1	7.9 x 10-1
Norfolk	1.0 x 10-5	6.0 x 10-1	6.0 x 10-6	2.1	3.0
Portsmouth	1.0 x 10-5	3.4 x 10-1	3.4 x 10-6	2.1	1.6
Kesselring	1.0 x 10-5	2.5 x 10-1	2.5 x 10-6	2.1	2.9 x 10-1
Accidental Criticality					
*INEL	1.0 x 10-5	6.4 x 10-3	6.4 x 10-8	8.0	9.2 x 10-3
Puget Sound	1.0 x 10-5	2.8 x 10-1	2.8 x 10-6	8.0	1.3
Pearl Harbor	1.0 x 10-5	6.0 x 10-1	6.0 x 10-6	8.0	6.7 x 10-1
Norfolk	1.0 x 10-5	3.5 x 10-1	3.5 x 10-6	8.0	2.7
Portsmouth	1.0 x 10-5	1.5 x 10-1	1.5 x 10-6	8.0	1.4
Kesselring	1.0 x 10-5	1.1 x 10-1	1.1 x 10-6	8.0	2.3 x 10-1
Mechanical Damage					
*INEL	1.0 x 10-5	5.3 x 10-6	5.3 x 10-11	5.2 x 10-4	2.6 x 10-6
Puget Sound	1.0 x 10-5	7.2 x 10-5	7.2 x 10-10	5.2 x 10-4	1.7 x 10-4
Pearl Harbor	1.0 x 10-5	1.5 x 10-4	1.5 x 10-9	5.2 x 10-4	9.3 x 10-5
Norfolk	1.0 x 10-5	8.0 x 10-5	8.0 x 10-10	5.2 x 10-4	3.5 x 10-4
Portsmouth	1.0 x 10-5	5.6 x 10-5	5.6 x 10-10	5.2 x 10-4	1.9 x 10-4
Kesselring	1.0 x 10-5	6.0 x 10-5	6.0 x 10-10	5.2 x 10-4	3.6 x 10-5

Airplane Crash					
Pearl Harbor	2.0 x 10-5	4.6 x 10-2	9.2 x 10-7	1.6 x 10-1	2.8 x 10-2
Norfolk	4.0 x 10-7	2.4 x 10-2	9.6 x 10-9	1.6 x 10-1	1.1 x 10-1
Kesselring	2.0 x 10-7	1.8 x 10-2	3.6 x 10-9	1.6 x 10-1	1.1 x 10-2
HEPA Filter Fire					
*INEL	5.0 x 10-4	5.3 x 10-5	2.7 x 10-8	2.4 x 10-3	2.5 x 10-5
Puget Sound	5.0 x 10-4	6.4 x 10-4	3.2 x 10-7	2.4 x 10-3	1.6 x 10-3
Pearl Harbor	5.0 x 10-4	1.2 x 10-3	6.0 x 10-7	2.4 x 10-3	8.7 x 10-4
Norfolk	5.0 x 10-4	6.9 x 10-4	3.5 x 10-7	2.4 x 10-3	3.3 x 10-3
WET STORAGE AND EXAMINATION ACCIDENTS					
Portsmouth	5.0 x 10-4	3.9 x 10-4	2.0 x 10-7	2.4 x 10-3	1.7 x 10-3
Kesselring	5.0 x 10-4	3.3 x 10-4	1.7 x 10-7	2.4 x 10-3	3.5 x 10-4
Minor Water Pool Leak					
*INEL	1.0 x 10-1	1.3 x 10-8	1.3 x 10-9	N/A	2.5 x 10-9
Puget Sound	1.0 x 10-1	4.2 x 10-9	4.2 x 10-10	N/A	3.2 x 10-10
Pearl Harbor	1.0 x 10-1	4.6 x 10-10	4.6 x 10-11	N/A	1.3 x 10-10
Norfolk	1.0 x 10-1	1.8 x 10-9	1.8 x 10-10	N/A	2.7 x 10-10
Portsmouth	1.0 x 10-1	1.4 x 10-9	1.4 x 10-10	N/A	1.3 x 10-10
Kesselring	1.0 x 10-1	8.5 x 10-9	8.5 x 10-10	N/A	6.0 x 10-9
DRY STORAGE ACCIDENTS					
Mechanical Damage					
Puget Sound	1.0 x 10-5	1.7 x 10-2	1.7 x 10-7	5.6 x 10-2	3.9 x 10-2
Pearl Harbor	1.0 x 10-5	3.0 x 10-2	3.0 x 10-7	5.6 x 10-2	2.1 x 10-2
Norfolk	1.0 x 10-5	1.8 x 10-2	1.8 x 10-7	5.6 x 10-2	8.1 x 10-2
Portsmouth	1.0 x 10-5	1.0 x 10-2	1.0 x 10-7	5.6 x 10-2	4.2 x 10-2
Kesselring	1.0 x 10-5	7.4 x 10-3	7.4 x 10-8	5.6 x 10-2	8.1 x 10-3
Airplane Crash					
Pearl Harbor	1.0 x 10-5	26	2.6 x 10-4	92	19
Norfolk	1.0 x 10-6	16	1.6 x 10-5	92	72
Portsmouth	1.0 x 10-7	9.0	9.0 x 10-7	92	38
Kesselring	1.0 x 10-7	7.5	7.5 x 10-7	92	7.7
DRY CELL ACCIDENTS					
Mechanical Damage					
*INEL	1.0 x 10-4	3.5 x 10-4	3.5 x 10-8	1.0 x 10-1	2.2 x 10-4
Loss of Shielding					
*INEL	1.0 x 10-5	3.0 x 10-19	3.0 x 10-24	7.2 x 10-5	9.3 x 10-17

*Information applicable only for full examinations at INEL.

Table F-7. Impacts from naval spent nuclear fuel facility radiological accidents for Planning Basis, Centralization at INEL, and Regionalization at INEL alternatives.

Accident Description	Probability (per year)	Consequences to Public (fatalities per accident)	Risk to Public (fatalities)	Dose to Worker (rem)	Dose to MOI (rem)
WET STORAGE AND EXAMINATION ACCIDENTS					
Drained Water Pool					
INEL	1.0 x 10-5	1.7 x 10-2	1.7 x 10-7	2.1	1.7 x 10-2
Accidental Criticality					
INEL	1.0 x 10-5	6.4 x 10-3	6.4 x 10-8	8.0	9.2 x 10-3
Mechanical Damage					
INEL	1.0 x 10-5	5.3 x 10-6	5.3 x 10-11	5.2 x 10-4	2.6 x 10-6
HEPA Filter Fire					

INEL	5.0 x 10-4	5.3 x 10-5	2.7 x 10-8	2.4 x 10-3	2.5 x 10-5
Minor Water Pool Leak					
INEL	1.0 x 10-1	1.3 x 10-8	1.3 x 10-9	N/A	2.5 x 10-9
DRY STORAGE ACCIDENTS					
Mechanical Damage					
INEL	1.0 x 10-5	4.9 x 10-4	4.9 x 10-9	5.6 x 10-2	4.6 x 10-4
DRY CELL ACCIDENTS					
Mechanical Damage					
INEL	1.0 x 10-4	3.5 x 10-4	3.5 x 10-8	1.0 x 10-1	2.2 x 10-4
Loss of Shielding					
INEL	1.0 x 10-5	3.0 x 10-19	3.0 x 10-24	7.2 x 10-5	9.3 x 10-17

Table F-8. Impacts from naval spent nuclear fuel facility radiological accidents for Regionalization or Centralization at other DOE sites alternatives.

Information applicable only to DOE site selected for Regionalization or Centralization.

Accident Description	Probability (per year)	Consequences to Public (fatalities per accident)	Risk to Public (fatalities)	Dose to Worker (rem)	Dose to MOI (rem)
WET STORAGE AND EXAMINATION ACCIDENTS					
Drained Water Pool					
Savannah Rive	1.0 x 10-5	1.1 x 10-1	1.1 x 10-6	2.1	1.6 x 10-2
Hanford	1.0 x 10-5	4.7 x 10-2	4.7 x 10-7	2.1	6.3 x 10-3
Nevada Test S	1.0 x 10-5	1.9 x 10-3	1.9 x 10-8	2.1	3.3 x 10-2
Oak Ridge	1.0 x 10-5	1.8 x 10-1	1.8 x 10-6	2.1	5.2
Accidental Criticality					
Savannah Rive	1.0 x 10-5	4.5 x 10-2	4.5 x 10-7	8.0	9.4 x 10-3
Hanford	1.0 x 10-5	1.6 x 10-2	1.6 x 10-7	8.0	2.8 x 10-3
Nevada Test S	1.0 x 10-5	7.0 x 10-4	7.0 x 10-9	8.0	2.0 x 10-2
Oak Ridge	1.0 x 10-5	8.8 x 10-2	8.8 x 10-7	8.0	4.7
Mechanical Damage					
Savannah Rive	1.0 x 10-5	2.0 x 10-5	2.0 x 10-10	5.2 x 10-4	2.2 x 10-6
Hanford	1.0 x 10-5	8.6 x 10-6	8.6 x 10-11	5.2 x 10-4	9.8 x 10-7
Nevada Test S	1.0 x 10-5	5.6 x 10-7	5.6 x 10-12	5.2 x 10-4	4.6 x 10-6
Oak Ridge	1.0 x 10-5	3.4 x 10-5	3.4 x 10-10	5.2 x 10-4	5.9 x 10-4
Airplane Crash					
Savannah Rive	2.0 x 10-6	6.1 x 10-3	1.2 x 10-8	1.6 x 10-1	6.4 x 10-4
Oak Ridge	1.0 x 10-6	1.0 x 10-2	1.0 x 10-8	1.6 x 10-1	1.8 x 10-1
Nevada Test S	4.0 x 10-7	1.7 x 10-4	6.8 x 10-11	1.6 x 10-1	1.3 x 10-3
HEPA Filter Fire					
Savannah Rive	5.0 x 10-4	1.3 x 10-4	6.5 x 10-8	2.4 x 10-3	2.1 x 10-5
Hanford	5.0 x 10-4	5.3 x 10-5	2.7 x 10-8	2.4 x 10-3	7.0 x 10-6
Nevada Test S	5.0 x 10-4	5.7 x 10-6	2.9 x 10-9	2.4 x 10-3	4.3 x 10-5
Oak Ridge	5.0 x 10-4	2.2 x 10-4	1.1 x 10-7	2.4 x 10-3	5.7 x 10-3
Minor Water Leak					
Savannah Rive	1.0 x 10-1	1.3 x 10-9	1.3 x 10-10	N/A	7.9 x 10-10
Hanford	1.0 x 10-1	1.7 x 10-10	1.7 x 10-11	N/A	9.9 x 10-12
Nevada Test S	1.0 x 10-1	1.4 x 10-9	1.4 x 10-10	N/A	2.5 x 10-9
Oak Ridge	1.0 x 10-1	3.9 x 10-9	3.9 x 10-10	N/A	1.5 x 10-9
DRY STORAGE ACCIDENTS					
Mechanical Damage					
Savannah Rive	1.0 x 10-5	3.0 x 10-3	3.0 x 10-8	5.6 x 10-2	4.9 x 10-4
Hanford	1.0 x 10-5	1.3 x 10-3	1.3 x 10-8	5.6 x 10-2	1.7 x 10-4
Nevada Test S	1.0 x 10-5	5.3 x 10-5	5.3 x 10-10	5.6 x 10-2	8.8 x 10-4

Oak Ridge	1.0 x 10-5	5.1 x 10-3	5.1 x 10-8	5.6 x 10-2	1.4 x 10-1
Airplane Crash					
Savannah Rive	3.0 x 10-7	2.8	8.4 x 10-7	92	4.7 x 10-1
Oak Ridge	3.0 x 10-7	4.7	1.4 x 10-6	92	120
DRY CELL ACCIDENTS					
Mechanical Damage					
Savannah Rive	1.0 x 10-4	1.4 x 10-3	1.4 x 10-7	1.0 x 10-1	2.4 x 10-4
Hanford	1.0 x 10-4	5.3 x 10-4	5.3 x 10-8	1.0 x 10-1	7.1 x 10-5
Nevada Test S	1.0 x 10-4	3.7 x 10-5	3.7 x 10-9	1.0 x 10-1	4.0 x 10-4
Oak Ridge	1.0 x 10-4	2.5 x 10-3	2.5 x 10-7	1.0 x 10-1	5.8 x 10-2
Loss of Shielding					
Savannah Rive	1.0 x 10-5	3.0 x 10-16	3.0 x 10-21	7.2 x 10-5	6.7 x 10-15
Hanford	1.0 x 10-5	4.9 x 10-24	4.9 x 10-29	7.2 x 10-5	3.3 x 10-23
Nevada Test S	1.0 x 10-5	3.7 x 10-37	3.7 x 10-42	7.2 x 10-5	6.3 x 10-11
Oak Ridge	1.0 x 10-5	7.5 x 10-6	7.5 x 10-11	7.2 x 10-5	1.2 x 10-2
Airplane Crash					
Savannah Rive	2.0 x 10-6	4.8	9.6 x 10-6	160	8.2 x 10-1
Oak Ridge	1.0 x 10-6	8.4	8.4 x 10-6	160	350
Nevada Test S	4.0 x 10-7	1.8 x 10-1	7.2 x 10-8	160	1.6

concentrations were then compared against Emergency Release Planning Guide (ERPG) levels as a means of evaluating their effects. ERPG values are specific for each substance and provide an estimate of the airborne concentration thresholds above which one can reasonably observe adverse effects. Exposure to an ERPG-1 level could result in a very mild effect whereas exposure to an ERPG-3 level could result in a life-threatening health effect. For the postulated accident involving a chemical spill and fire, on-site personnel (worker) could be exposed to concentrations of hydrochloric acid, phosgene, sulfuric acid, and sodium hydroxide above ERPG-3 levels which indicates a potential for long-term health effects. However, no member of the general public located off-site would be expected to be exposed to levels above ERPG-3 except for Oak Ridge where sulfuric acid and sodium hydroxide concentrations could exceed ERPG-3. For the postulated accident involving a diesel fuel fire, on-site personnel could be exposed to concentrations of sulfur dioxide and oxides of nitrogen above ERPG-3 levels. No member of the general public located off-site would be expected to be exposed to levels above ERPG-3 except for Oak Ridge where sulfur dioxide and oxides of nitrogen concentrations could exceed ERPG-3 and one shipyard location (Norfolk) where nitric oxide concentrations could exceed ERPG-3 under severe meteorological conditions. However, for both postulated accidents, the accident analyses did not include evacuation of on-site or off-site personnel and it is expected that chemical exposures would be below ERPG-3 levels because actions such as evacuation would be used to reduce the effects on the public and workers.

Fugitive Dust Analysis

The FDM computer code was used to estimate the fugitive dust concentrations that could result from the construction of a water pool facility at the alternate locations. It was determined that the release of fugitive dust would not result in any adverse effects for any of the alternate locations.

Other Impacts

The radiological impact of accidents on the environs of a facility was determined by examining the area that could be contaminated following such an event. Calculations using average meteorological conditions were performed for each accident scenario. These calculations determined the extent of the contamination which causes only a small increase in background radiation from naturally occurring sources. For most facilities and most accidents, the contaminated area was confined to the boundaries of the site. For a few cases, the casualty scenarios did result in contaminated land outside the site boundaries; however, the total land contaminated for those scenarios (inside and outside the boundary) was no more than 207 acres. The impact of this contamination would be temporary while the area was isolated and remediation efforts completed.

F.1 RADIOLOGICAL ISSUES FROM NAVAL SPENT NUCLEAR FUEL

INSPECTIONS AND STORAGE

Naval spent nuclear fuel is currently examined and stored at the Naval Reactors Facility's Expended Core Facility (ECF) at the DOE Idaho National Engineering Laboratory (INEL). The INEL-ECF is a large laboratory facility used to receive, examine, and ship naval spent nuclear fuel and irradiated test specimen assemblies. Enclosed work areas at INEL-ECF include an array of interconnected reinforced concrete water pools which permit visual observation of naval spent nuclear fuel during handling and inspection while shielding workers from radiation. Adjacent to the water pools are shielded cells used for operations which must be performed dry. One of the water pools contains transfer canals that will link the water pools with a proposed Dry Cell Project, which would provide a location for preparation of spent fuel in a dry, enclosed environment.

The proposed Dry Cell Facility will consist of a shielded, radiologically controlled area built of structural steel and concrete with remotely operated equipment necessary to examine fuel modules.

The Organization for Economic Co-operation and Development (OECD) of the Nuclear Energy Agency (NEA) reported that extensive safety analysis has shown that pool storage of Zircaloy-clad fuel is a very safe option which can last for decades (NEA 1993). The external hazards, such as earthquakes and aircraft crashes, are potential threats for these facilities (loss of coolant) but appropriate siting, design, and additional shielding can cope with these hazards. Dry storage has not yet generally been carried out on a very large scale but it is anticipated that long-term storage in adequate canisters is a very safe practice even against earthquakes and aircraft crashes.

Several technologies are being used currently for the storage of spent fuel at reactor sites and at sites away from reactors. Both wet (pool) storage facilities and dry storage facilities (buildings and containers) are used on a commercial scale.

The safety of spent fuel storage has been extensively evaluated. The U.S. Nuclear Regulatory Commission (NRC) reported in the "Waste Confidence Decision" of 1984 that there is reasonable assurance that spent fuel can be stored safely and without significant environmental impact in reactor pools or in spent fuel storage installations (NUREG 1984). For both dry storage and wet storage, the NRC stated its belief that current storage technologies are capable of providing safe storage for at least 30 years beyond the active lifetime of the reactor facility. The NRC also concluded that the possibility of a major accident or sabotage at a spent fuel storage facility with radiological consequences for the public is extremely remote.

Considerable experience has been gained in the transport of spent fuel elements and in the consequent safety-related development of suitable transportation casks. This experience has made it possible to develop a concept for dry storage of spent fuel elements within transportation casks; dry storage containers generally have not been the transportation casks themselves.

The concept of a cask which could be used for both transportation and storage has been licensed in the United States in the framework of a policy of dry storage in Independent Spent Fuel

Storage Installations (CFR 1993). According to this policy, the reactor operators are entitled to store the spent fuel elements, which have cooled in a pool for at least one year after discharge from the reactor, in specially licensed containers under dry conditions for 20 years or more. A number of storage casks have received official approval for that purpose.

F.1.1 Normal Operations

Current practice for examination of naval spent nuclear fuel at ECF includes removal of upper and lower non-fuel bearing structures, visual examination, measurement of key dimensions, collection of specimens, and loading into a shipping cask. Temporary storage of spent fuel at INEL-ECF is required since fuel is, at times, received into the facility faster than it can be examined and shipped out of the facility. In addition, a small amount of spent fuel is selected for retention as library specimens for future reference and examination. Routine releases to the atmosphere were evaluated at all locations based on measured releases from INEL-ECF. Each location was evaluated using releases equivalent to those of INEL-ECF. Each location's specific population and meteorology were then used to produce estimated consequences.

F.1.1.1 Water Pool Storage. Wet storage is a highly developed technique and it is the standard

method used worldwide for storage of spent fuel. While in wet storage pools, temperatures, pressures, and radiation fluxes are lower than in the reactor, so there is no intrinsic driving force for the sudden release of a major fraction of the radioactive materials contained in the stored spent fuel.

The Zircaloy cladding of naval spent nuclear fuel is an efficient barrier against fission product release during handling and storage of spent fuel. Given adequate control of water purity, Zircaloy resists corrosion in water during the long-term storage conditions of fuel assemblies. At the end of its service life, the fuel is covered with a tightly adhering oxide layer formed at high temperatures which is a major factor that inhibits further corrosion during storage.

Direct exposure to radiation of persons working in storage facilities can occur during such activities as handling of fuel casks and fuel assemblies, handling of contaminated filters, and repair and maintenance work. Experience shows that, in common with other fuel cycle facilities, the risk of increased occupational exposure arises when any maintenance or unusual operations are carried out. Such increased exposures can, however, generally be minimized by good planning, adequate redundancy of critical components, paying particular attention to the design of those items that are liable to become contaminated from the point of view of repair and maintenance, and by the use of local shielding and equipment decontamination procedures. Systems and components that are important in this context include:

- pool water cooling and makeup systems;
- filter equipment for purification of pool water;
- ventilation systems;
- equipment for temperature, water level, and leakage measurement in the fuel pools;
- hoists and handling systems for fuel assemblies; and
- equipment for handling and storage of other wastes.

Shielding from radiation is normally assured by providing a minimum depth of water above the fuel elements in storage to reduce the exposure rates. Fuel transfer mechanisms have limit switches and mechanical stops to prevent the inadvertent raising of fuel to the water surface. A high-integrity pool structure is needed in order to guarantee adequate containment of the pool water, but a limited loss of water resulting in a substantial reduction of the shielding layer is unlikely to involve high risks of exposures to personnel above operational limits since adequate countermeasures can be taken in time.

Storage of naval spent nuclear fuel in water pools is an alternative being evaluated at all DOE and Navy shipyard locations discussed above. Source terms for all locations were based on actual releases reported by INEL-ECF in the past. Exposures due to downwind dispersion, water release, and direct radiation were calculated.

F.1.1.2 Dry Storage. Many thousands of spent fuel assemblies of different types have been stored for

periods of time ranging from a couple of years to over 30 years in more than 20 different dry storage facilities. In general, the spent fuel behavior during storage has been excellent and no detrimental effects of dry storage on the integrity of the spent fuel have been detected (NEA 1993).

The dry storage of spent fuel is being used to a limited extent in several countries. In the United States, fuel was stored in dry wells at the INEL. Dry wells were used for the storage of a small amount of fuel at the Nevada Test Site as part of a large dry storage demonstration program. Storage started at the Climax deep dry wells (600 meters below the surface in granite) in 1979. In 1983, one fuel assembly underwent extensive non-destructive and destructive characterization. No problems requiring process changes were identified (NEA 1993).

Designs of metal casks for use in spent fuel storage have been in existence since the late 1970s. The casks are generally equipped with a double-lid system to ensure safe containment of contents. These casks have been subjected to a variety of tests and demonstrations since the early 1980s using both intact and consolidated fuel.

The DOE sponsored the demonstration of the storage of fuel in metal casks at the Morris storage facility in 1984 and 1985. The DOE entered into a cooperative agreement with Virginia Power, a United States' utility, to demonstrate the use of three types of metal casks. The Virginia Power Surry Nuclear Power Station has been licensed by the NRC for storage of spent fuel in metal casks.

Results of demonstration activities have shown the following (NEA 1993):

- radiation and thermal levels resulting from metal cask storage have been acceptable;
- no fuel failure has occurred during demonstration storage;
- no secondary wastes have arisen from the storage operation.

Storage of naval spent nuclear fuel in storage or shipping containers is an alternative being evaluated at all locations. Since no airborne releases are expected from routine dry storage activity, only the biological effects of direct radiation exposure to the on-site personnel and the public were determined.

F.1.1.3 Dry Cell Operations. The handling of naval spent nuclear fuel for research and development

purposes in dry cells like the proposed Dry Cell Project was evaluated at selected DOE locations. The health effects due to routine airborne releases and direct radiation exposure were estimated.

F.1.2 Screening/Selection of Accidents for Detailed Examination

Accidents were considered for inclusion in detailed analyses if they were expected to contribute substantially to risk (defined as the product of the probability of occurrence of the accident times the consequence of the accident). Accidents were categorized into three types as either Abnormal Events, Design Basis Accidents, or Beyond Design Basis Accidents. These categories are characterized by their probability of occurrence as described further in Section F.1.3.7. Construction and industrial accidents are included in these categories.

In selecting accidents to include in detailed analyses, several considerations were utilized. Initiating events were reviewed including natural phenomena (earthquakes, volcanic activity, tornadoes, hurricanes and other natural events) and human initiated events (human error, equipment failures, fires, explosions, plane crashes, transportation accidents, and terrorism). Guiding principles were established, such as: the radioactive materials involved must be available in a dispersible form; there must be a mechanism available for release of such materials from the facility; and, there must be a mechanism available for off-site dispersion of the released materials. The pathways whereby members of the public can be affected from the nuclear aspects of spent fuel operations are direct exposure to radiation, inhalation of radioactive materials, or ingestion of radioactive materials. Recognizing these fundamental processes and pathways, accidents involving the following basic phenomena were identified:

- loss of shielding of radioactive materials,
- release of radioactive products to the environment due to overheating of fuel,
- release of radioactive products to the environment due to mechanical shock or damage or inadvertent breaching of fuel cladding or containment,
- an unplanned criticality,
- transportation accidents.

After the basic phenomena were identified, other references were consulted to ensure that all important accidents were considered. These included safety analysis reports, court decisions, other environmental impact statements, and summary documents such as the "Final Generic Environmental Impact Statement on Handling and Storage of Spent Light Water Reactor Power Reactor Fuel" (NUREG 1979a) and "The Safety of the Nuclear Fuel Cycle" (NEA 1993).

Examining the kinds of accidents which could result in release of radioactive material to the environment or an increase in radiation levels shows that they can only occur if an accident produces severe conditions. Some types of accidents, such as procedure violations, spills of small volumes of water containing radioactive particles, or most other types of common human error, may occur more frequently than the more severe accidents analyzed. However, they do not involve enough radioactive material or radiation to result in a significant release to the environment or a meaningful increase in radiation levels. Stated another way, the very low consequences associated with these events produce smaller risks than those for the accidents analyzed, even when combined with a higher probability of occurrence. Consequently, they have not been included in the results presented in this Environmental Impact Statement.

Acts of terrorism are expected to result in consequences which are bounded by the results of accidents which were evaluated. Naval spent nuclear fuel is not considered to be attractive to terrorists due to the bulk of the fuel and containers and due to the high radiation fields involved with unshielded spent nuclear fuel. However, terrorist attacks on naval spent nuclear fuel during shipment were evaluated. The massive structure of the shipping containers used for naval spent nuclear fuel makes them an unlikely target of a terrorist attack. No such attacks have occurred in the nearly 40 years of rail shipments which have now travelled about 2 million kilometers. Thus, the probability of a terrorist attack on a shipment is judged to be no more than the probability of a rail accident which is listed in Section A.7.1.2.1 of Attachment A to Appendix D of this Environmental Impact Statement. The consequences of a terrorist attack are also judged to be no more severe than those listed for transportation accidents. Therefore, the same conclusions reached for transportation accidents apply to the risk to the extremely rugged shipping containers from terrorist attack during a shipment. In addition, during shipment, all naval spent nuclear fuel containers are accompanied by escorts who remain in contact with headquarters. In the event of an emergency, state and federal resources would be quickly summoned to stabilize the situation.

For an act of war, sabotage, or terrorist attack, it is likely the risk would be lower than calculated for the airplane crash because it should be less probable that a force would exist to disperse radioactive products into the atmosphere from a weapon as compared to the motive force of the fire assumed in the case of an airplane crash. For example, attacks on containers using anti-tank weapons would be less severe than the accidents analyzed because: (a) anti-tank weapons would cause a self-sealing penetration in the metal of a container, unlike that which is assumed from the airplane crash (impact from a 50-inch diameter engine rotor); (b) there is no explosive material inside the container, so it will not "blow up" as a tank would if hit by such a weapon (in a tank attack, the tank shells inside the turret detonate); (c) there would be no fire to disperse the radioactivity that is released when the container is breached, unlike an aircraft crash where the jet fuel will burn creating such a fire. The rugged design of containers and the thick walls of water pools, combined with the shock-absorbing nature of water with a free surface, reduce the effects of other types of explosive charges. It is not credible that a terrorist attack would result in a criticality or meltdown of spent nuclear fuel; however, in Section F.1.4.2.1.2, the consequences of a hypothetical criticality accident are presented. The risks associated with an accidental criticality are less than those associated with a drained water pool or an airplane crash into dry storage containers.

The effect of a terrorist attack or an act of sabotage is expected to be conservatively bounded by the limiting accident discussed at each facility under each alternative. For example, the most limiting accident involving naval spent nuclear fuel is described in this attachment to be an airplane crash into a shipping container at the Pearl Harbor Naval Shipyard. This accident would lead to 26 latent fatal cancers over the next 50 years in the population within 50 miles of the shipyard. Since the probability of the event is one chance in 100,000 per year, the risk would be 0.00026 latent fatal cancer fatalities per year or, in other words, about one chance in 4,000 of a single latent fatal cancer fatality over a year. This risk is shared among the approximately 820,000 people residing within 50 miles of the shipyard who would be expected to have over 2,000 cancer fatalities from all causes every year. For an act of war, sabotage, or terrorist attack, it is likely the risk would be lower than calculated because it should be less probable that a force would exist to disperse radioactive products into the atmosphere from a weapon as compared to the motive force of the fire assumed in the case of an airplane crash.

Accidents initiated at nearby facilities, by other activities unrelated to spent nuclear fuel handling or storage, or during construction of an ECF or dry cell type of facility, would not produce effects more severe than the sequences of events described. This is because naval spent nuclear fuel undergoing examination or in storage under the conditions of the alternatives evaluated would not need special conditions or uninterrupted operator attention to prevent overheating, failure of containment, or loss of shielding. Therefore, evacuation in response to an accident at some other facility would not compromise safety. This inherent safety, combined with the distance between naval spent nuclear fuel facilities and any other activities which might suffer a catastrophic accident, means that the accidents analyzed in this document produce conditions at a naval spent nuclear fuel facility which would be more severe than those for any hypothetical synergistic combination of events resulting from accidents at other, unrelated facilities. Therefore, such analyses have not been included in this evaluation.

The existence of common cause accidents at a facility has been considered. In general, only one spent nuclear fuel facility is located at a particular Navy site. However, it is possible for natural phenomena, like an earthquake, to produce more than one accident at some sites causing a situation resulting in the release of radioactive material into the atmosphere or an increase in radiation levels due to loss of shielding. However, the probability of two or more accidents having maximum consequences occur concurrently is less than the probability of the individual events. For example, if an earthquake affected the Naval Reactors Facility at INEL, a crane might fail causing damage to stored spent fuel, the water pool might drain, and shielding for the Dry Cell might be damaged. The impacts for this could conservatively be estimated by summing the consequences. A combined total of 2.8 x 10-2 fatal cancers are estimated. Similarly, consequences from spent nuclear fuel facilities within a DOE site could be combined to conservatively estimate site wide impacts. But again, the probability of a common cause event resulting in this number of consequences is lower than the probability of the individual accidents because the severity of impact will vary between facilities due to separation distances.

Several accident scenarios were developed for the handling and storage of naval spent nuclear fuel. All potential accidents were not evaluated, but cases which are considered to be more severe than all other reasonable accidents were analyzed. Each of these accident scenarios was evaluated at several locations using identical source terms. Like the evaluations for normal operations, population and meteorology data specific to each site were used to estimate site specific health effects.

F.1.2.1 Water Pool Storage. Six hypothetical accident scenarios were evaluated for naval spent

nuclear fuel stored in water pools. These hypothetical sequences of events include a drainage of the water pool caused by an earthquake, an accidental criticality, mechanical damage due to operator error or crane failure, an airplane crash into the water pool facility, a fire in a high efficiency particulate air (HEPA) filter, and minor water pool leakage. Radiation exposure to on-site individuals, an individual at the site boundary, and the general population was estimated for airborne releases of radioactivity, water releases, and direct radiation exposure.

F.1.2.2 Dry Storage. Two hypothetical accident scenarios were evaluated for naval spent nuclear fuel

stored in shipping containers. The first scenario postulates that a wind-driven missile crashes into storage casks, with mechanical damage causing a release of corrosion products into the environment. The second hypothetical scenario is based on an airplane crash into the dry storage area. Once again, radiation exposure to on-site individuals, an individual at the site boundary, and the general population was estimated for airborne releases, water releases, and direct radiation exposure.

F.1.2.3 Dry Cell Operations. Three hypothetical accidents were evaluated for naval spent nuclear fuel

handled in dry cells at several locations. These scenarios include cutting into the fuel region or mechanical damage during examination work, partial loss of concrete shielding due to an earthquake, and an airplane crash into the dry cell facility. Once again, radiation exposure to on-site individuals, an individual at the site boundary, and the general population was estimated for airborne releases, water releases, and direct radiation exposure.

F.1.2.4 Shipboard Fire Involving Shipping Containers. Attachment A describes the historical

practice of shipping naval spent nuclear fuel from Pearl Harbor Naval Shipyard to Puget Sound Naval Shipyard by ship where the containers are then transported to ECF by rail. Since 1962, there have been 17 shipments containing a total of 20 shipping containers. Even though there have not been any accidents involving these shipments, hypothetical accidents were evaluated near the Pearl Harbor and Puget Sound shipyards. The scenario involves a collision of the spent nuclear fuel ship with another ship which results in a fire. The radiation exposure to nearby individuals and the general population was estimated for airborne and water releases.

F.1.3 Analysis Methods for Evaluation of Radiation Exposure

F.1.3.1 General. An evaluation of normal operations and hypothetical accidents at the existing and proposed sites was performed to assess the possible radiation exposure to individuals due to the release of radioactive materials. The analyses are based on the same operations carried out at the different potential locations and the same accidents at any of the sites evaluated. With this approach, it is possible to compare the incremental effect of the proposed alternative actions or the different impacts of the postulated accidents at the different sites. These locations include four naval shipyards (Portsmouth, Norfolk, Puget Sound, and Pearl Harbor), five Department of Energy facilities (INEL, Savannah River, Hanford, Nevada Test Site, and Oak Ridge), and the Kesselring Site.

F.1.3.2 Exposures to be Calculated. Radiation exposure to the following different individuals and the general population is calculated for normal operation of the spent fuel facility and for accident conditions:

- Worker (Worker). An individual located 100 meters (330 feet) from the radioactive material release point. (The impact of accidents on close-in workers is not calculated numerically but is discussed qualitatively for each accident in Section F.1.4.3 of this attachment.)

- Maximally exposed collocated worker (MCW). At DOE locations, a theoretical individual located at whichever is the greater of 0.4 mile from the facility area boundary or 75% of the distance to the nearest independent facility area. The MCW is not evaluated if the site boundary is closer than the MCW location. Thus, at shipyard locations and the Kesselring Site, the MCW is not specifically evaluated.

- Maximally exposed off-site individual (MOI). A theoretical individual living at the DOE site or shipyard boundary receiving the maximum exposure. At the Savannah River Site, two separate MOI locations were evaluated depending upon whether the spent fuel facility is constructed on the Savannah River Site or is located at the existing Barnwell Nuclear Fuel Plant (hereafter referred to as the Barnwell Plant) which is adjacent to the Savannah River Site. At Hanford, two separate MOI locations were also evaluated depending upon whether a new facility is constructed in the 200 Area or modifications are made to the Fuels and Materials Examination Facility (FMEF) which is located in the 400 Area.

- Nearest public access individual (NPA). At larger DOE sites, highways used by the public may cross the federal reservation which includes the facility where naval spent nuclear fuel operations could be conducted. Consequently, these analyses included evaluation of the exposure to a theoretical motorist who might be stranded on such a highway at the time of an accident. Based on experience from emergency exercises, emergency response teams would be able to evacuate such an individual within 2 hours, so this was the exposure time used in the calculations. At naval shipyard locations, no public access highways exist, but military personnel, civilian employees, or their family members, including some who reside on the base, may be located outside the controlled industrial area boundary but inside the confines of the military base. Such personnel might be at their homes, in buildings, or on the roadways of the base at the time of an accident or at any time throughout the year for the evaluation of normal operations. The base residents are used as the NPA individuals at these shipyards for analyses of normal operations. In the event of a severe accident they would be evacuated within 2 hours under military control of the base, so this time was used in accident calculations. No NPA value was calculated for the Kesselring Site and the Nevada Test Site because there are no public roads which cross these sites, there are no residents, and there are no other public accesses.

- Maximally exposed individual at nearby communities is evaluated for accidents.
- General population within a 50-mile radius of the facility.

Exposure is calculated to result from direct radiation from the facility and exposure to radioactive contamination released to the air. Normal releases directly to the water pathway occur only at shipyards which are located directly on bodies of water, and contamination of the water at all sites results from fallout of airborne contamination. The releases to the air might result in exposure through several pathways described as follows:

- External direct exposure from immersion in the airborne radioactive material (air immersion)
- External direct exposure from radioactive material deposited on the ground (ground surface)
- Internal exposure from inhalation of radioactive aerosols and suspended particles (inhalation)
- Internal exposure from ingestion of terrestrial food and animal products (ingestion)
- Exposure from contaminated water (water release).

The radiation exposure is calculated by the computer programs discussed in Section F.1.3.6 in a manner recommended by the International Commission on Radiological Protection (ICRP 1977; ICRP 1979). Weighting factors are used for various body organs to calculate a "committed effective dose equivalent" (CEDE) from radiation inside the body due to inhalation or ingestion. Committed dose equivalents (CDEs) are calculated for organs such as the lungs, stomach, small intestine, upper large intestine, lower large intestine, bone surface red bone marrow, testes, ovaries, muscle, thyroid, bladder, kidneys, liver etc. The CEDE value is the summation of the CDEs to the specific organ weighted by the relative risk to that organ compared to an equivalent whole-body exposure.

The programs also calculate an effective dose equivalent (EDE) for the external exposure pathways (immersion in the radioactive material, exposure to ground contamination) and a 50-year CEDE for the internal exposure pathways . The sum of the EDE from external pathways and the CEDE internal pathways is called the "total effective dose equivalent" (TEDE) in this Environmental Impact Statement (EIS) and is also calculated by the programs. The TEDE reported in the results section is the sum of the TEDE's from air, water, and direct radiation exposures.

The exposure from ingestion of terrestrial food and animal products is calculated on a yearly basis. However, it is expected that continued consumption of contaminated food products by the public would be suspended after a Protective Action Guideline is reached. In 1991, the Environmental Protection Agency recommended protective action guidelines in the range of 1 to 5 rem whole-body exposure. To ensure a consistent analysis basis, no reduction of exposure due to a Protective Action Guideline was accounted for in the analysis. This would result in a conservative approach which may slightly overestimate health effects within an exposed population, but allows for consistent comparisons between alternatives.

Table F.1.3.2-1 identifies selected nearby communities for each site for which hypothetical exposures for a maximally exposed individual were calculated. In all cases, the MOI exposure was greater than maximum exposure at any nearby community. Calculations were performed for these localities to evaluate exposures for areas representative of the range of communities within 50 miles of the sites analyzed. The selection of these communities was not intended to indicate that other localities were not important. Other communities of interest in the vicinity of the sites in addition to those evaluated include a number of communities in Maine and New Hampshire near the Portsmouth Naval Shipyard, including Portsmouth, Durham, Eliot, Greenland, Kittery, New Castle, North Hampton, Ogunquit, Rye, and South Berwick.

Table F.1.3.2-1. Nearby communities for each site.

INEL	Howe, Atomic City, Arco, Blackfoot, Idaho Falls
Savannah River	Snelling, Barnwell, Jackson, Aiken, Allendale, Augusta, Sylvania, Bamberg, Wrens
Hanford	Othello, Richland, Prosser, Pasco, Yakima, Umatilla
Nevada Test Site	Beatty, Pahrump, Las Vegas
Oak Ridge	Oak Ridge, Harriman, Rockwood, Knoxville, Jefferson City
Puget Sound	Seattle, Tacoma, Olympia, Port Angeles
Pearl Harbor	Pearl City, Aiea, Pacific Palisades, Ewa Beach, Honolulu, Ewa, Wahiawa
Norfolk	Newport News, Hampton, Suffolk, Virginia Beach, Williamsburg
Portsmouth	Dover, Exeter, Hampton Beach, Sanford, Nashua, Lowell, Concord, Portland, Boston
Kesselring	Ballston Spa, Saratoga Springs, Amsterdam, Schenectady, Corinth

Table F.1.3.2-2 presents an example of the detailed exposure calculation results which were performed. The table shows the possible exposure pathways and individuals analyzed.

F.1.3.3 Evaluation of Health Effects. Health effects are calculated from the exposure results. The risk factors used for calculations of health effects are taken from Publication 60 of the International Commission on Radiological Protection (ICRP 1991). Table F.1.3.3-1 lists the appropriate factors used in the analysis of both the normal operations and the hypothetical accident scenarios.

Cancer fatalities were used to summarize and compare the results in this Environmental Impact Statement since this effect was viewed to be of the greatest interest to most people. As shown in Table F.1.3.3-1, the number of total health effects (deaths, non-fatal cancers, genetic effects, and other impacts on human health) may be easily obtained by multiplying the latent cancer fatalities by the factor of 1.46, which is the ratio of 7.3/5.0.

The numerical estimates of cancer deaths and other health detriments presented were obtained by the practice of linear extrapolation from the nominal risk estimate for lifetime total cancer mortality at 10 rad. Other methods of extrapolation to the low-dose region could yield higher or lower numerical estimates of cancer deaths. Studies of human populations exposed at low doses are

Table F.1.3.2-2. Summary of exposure calculation results.

Location	Inhalation CEDE (rem)	Air Immersion EDE (rem)	Ground Surface EDE (rem)	Ingestion EDE (rem)	Total Airborne Release EDE (rem)	Water Release (rem)	Direct Radiation (rem)	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.4×10^{-1}	6.5×10^{-4}	7.9×10^{-1}	N/A	1.3	N/A	8.8×10^{-5}	1.3	5.3×10^{-4}
MCW	4.8×10^{-4}	8.6×10^{-7}	3.4×10^{-4}	N/A	8.2×10^{-4}	1.6×10^{-17}	3.8×10^{-8}	8.2×10^{-4}	4.1×10^{-7}
NPA	1.4×10^{-4}	3.2×10^{-7}	5.2×10^{-5}	N/A	1.9×10^{-4}	1.6×10^{-17}	3.4 x	1.9 x	9.5 x

						10-9	10-4	10-8	
MOI	6.1 x 10-4	1.2 x 10-6	7.8 x 10-4	3.1 x 10-4	1.7 x 10-3	3.0 x 10-5	9.6 x 10-9	1.7 x 10-3	8.6 x 10-7
Exposure to Maximally Exposed Individual at Nearby Communities (rem)									
Arco (30600m)	5.2 x 10-5	1.3 x 10-7	6.4 x 10-5	3.1 x 10-5	1.5 x 10-4	3.0 x 10-5	3.4 x 10-9	1.8 x 10-4	8.8 x 10-8
Howe (16100m)	9.8 x 10-5	1.8 x 10-7	1.2 x 10-4	5.6 x 10-5	2.7 x 10-4	3.0 x 10-5	3.4 x 10-9	3.0 x 10-4	1.5 x 10-7
Idaho Falls (72400m)	3.1 x 10-6	5.2 x 10-9	3.6 x 10-6	2.0 x 10-6	8.7 x 10-6	3.0 x 10-5	2.1 x 10-10	3.9 x 10-5	1.9 x 10-8
Blackfoot (68100m)	4.8 x 10-6	3.3 x 10-9	5.2 x 10-6	3.4 x 10-6	1.3 x 10-5	3.0 x 10-5	2.1 x 10-10	4.3 x 10-5	2.2 x 10-8
Atomic City (24200m)	2.9 x 10-5	1.0 x 10-7	3.6 x 10-5	1.6 x 10-5	8.1 x 10-5	3.0 x 10-5	3.4 x 10-9	1.1 x 10-4	5.6 x 10-8
									Number of Fatal Cancers
Exposure to Population within 50-mile Radius (person-rem)									
Population of 115690	1.1 x 10-1	6.1 x 10-5	1.5 x 10-1	4.5 x 10-2	3.0 x 10-1	3.8	5.3 x 10-6	4.1 10-1	2.1 x 10-3

Table F.1.3.3-1. Risk estimators for health effects from ionizing radiation.

		Risk Factor (probability per rem)*	
Effect	Nuclide	Worker	General Population
Fatal cancer (all organs)	All	4.0 x 10-4	5.0 x 10-4
Weighted non-fatal cancer**	All	8.0 x 10-5	1.0 x 10-4
Weighted genetic effects**	All	8.0 x 10-5	1.3 x 10-4
Weighted total effects**	All	5.6 x 10-4	7.3 x 10-4

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* For high individual exposures (y20 rem), the above risk factors are multiplied by a factor of two.
General population exposures were not modified because the large drop in exposure with increasing distances results in average exposure rates well below 20 rem.

** In determining a means of assessing health effects from radiation exposure, the ICRP has developed a weighting method for non-fatal cancers and genetic effects to obtain a total weighted effect, or "health detriment".

inadequate to demonstrate the actual level of risk. There is scientific uncertainty about cancer risk in the low-dose region below the range of epidemiologic observation, and the possibility of no risk cannot be excluded (CIRRPC 1992). In this appendix, the doses have been provided in all cases to allow independent evaluation using any relation between exposure and health effects.

F.1.3.4 Population. Population distributions specific to each site were used for the evaluations. The

population distributions were obtained from 1990 United States Census data. The population information was obtained in 16 compass directions and 5 equal radial distances from the likely location of a naval spent nuclear fuel site to a 50-mile total distance.

F.1.3.5 Meteorology. For the navy shipyards, Savannah River, and Kesselring Sites, the

meteorological data used in the analyses were obtained from the SCRAM bulletin board system. For the INEL, Hanford, Nevada Test Site, and Oak Ridge, site tower meteorological data were used. The SCRAM bulletin board is operated by the Support Center for Regulatory Air Models within the Environmental Protection Agency, Office of Air Quality Planning and Standards. The SCRAM surface meteorological data files are comprised of data acquired from the National Climatic Data Center. The SCRAM data for 4 or 5 years were used with programs from the bulletin board to develop meteorological data in the STability ARray (STAR) format which is a joint frequency distribution of 6 wind speed intervals, 16 wind directions, and 6 stability categories. The STAR data were reformatted into the format required by the GENII program, described below, for evaluation of normal operations.

The STAR data were also used to calculate the 50% and 95% meteorological conditions for the accident analyses. The 50% condition represents the average meteorological condition. This condition is defined as that for which more severe conditions with respect to accident consequences occur less than 50% of the time. The 95% condition represents the meteorological conditions which could produce the highest calculated exposures. This is defined as that condition which is not exceeded more than 5% of the time or is the worst combination of weather stability class and wind speed. Each of these conditions is evaluated for 16 wind directions.

For each location, the nearest available SCRAM data was used to represent the conditions at the site being evaluated. Table F.1.3.5-1 shows the pertinent data for the meteorological data application.

Table F.1.3.5-1. Meteorological data applicability.

Site	Data From	Data Years
Portsmouth	Portland ME Airport	1985-1989
Norfolk	Norfolk VA Airport	1985-1989
Puget Sound	SEATAC Airport	1985-1989
Pearl Harbor	Honolulu Airport	1985-1989
INEL	NRF Tower	1987-1991
Kesselring	Albany NY Airport	1985-1989
Savannah River	Augusta GA Airport	1984-1987
Hanford	200 Area Tower	1983-1990
Nevada Test Site	Desert Rock Tower	1990
Oak Ridge	Y-12 West Tower	1990

F.1.3.6 Computer Programs. Five computer programs were used to evaluate the radiation exposures

to the specified individuals and general population.

F.1.3.6.1 GENII. The code used for the environmental and transport and exposure assessment

calculations for normal operations was GENII (Napier et al. 1988). This code was developed at Pacific Northwest Laboratory by Battelle Memorial Institute to incorporate the internal dosimetry models recommended by the International Commission on Radiological Protection in Publication 26 (ICRP 1977) and Publication 30 (ICRP 1979) into environmental pathway analysis models in use at Pacific Northwest Laboratory.

Although GENII can be used to model both acute and chronic releases to the atmosphere, only the chronic option was used in the normal operations evaluation reflecting long-term average exposure to the released radioactive contaminants. For the chronic evaluations, the code also uses meteorological conditions averaged over each sector to reflect exposure to long-term average concentrations. The ingestion calculation used the modeling approach that exposed individuals within 50 miles of the site consumed 30% of milk products and 10% of all products grown locally where the people live.

F.1.3.6.2 RSAC-5. The computer code RSAC-5 was developed by Westinghouse Idaho

Nuclear Co, Inc., for the DOE-ID Operations Office and is in the public domain (Wenzel 1993). The code calculates the consequences of the release of radionuclides to the atmosphere. It allows the amount of each fission product nuclide from a nuclear event to be input individually or to be calculated internally by the code. RSAC-5 calculates potential radiation exposures to maximally exposed individuals or population groups via inhalation, ingestion, exposure to radionuclides deposited on the ground surface, immersion in airborne radioactive material, and radiation from a cloud of radioactive material. RSAC-5 meteorological capabilities include Gaussian plume dispersion for Pascal-Gifford conditions. RSAC-5 release scenario modeling allows reduction of nuclides by chemical group or element and calculates decay and buildup during transport through operations, facilities, and the environment. It also models the effect of filters or other cleanup systems. Population exposures are the product of the calculated individual exposure and the number of people in the affected population.

F.1.3.6.3 ORIGEN. ORIGEN (Croff 1980) is a computer code system for calculating the

buildup and decay of radioactive materials (fission products, actinides, and activation products). The code input was modeled to describe the naval nuclear fuel system and incorporates cross-section data that are distinct to naval fuels.

F.1.3.6.4 SPAN. SPAN (Wallace 1972) is the computer code which was used to calculate the

direct radiation levels. Attenuation from air was included in the calculated radiation levels. To determine the unit person exposure per sector, SPAN was used to integrate the radiation level over the sector. The radiation levels calculated at various distances were used as the source to represent the proper distance falloff in the sector, and a total radiation level for each sector was calculated. This total integrated radiation level for each sector was then divided by the sector volume, resulting in an "average" radiation exposure for any point within the sector.

F.1.3.6.5 WATER RELEASE. WATER RELEASE is an unpublished computer code used to

calculate exposures to humans arising from radionuclides which have been introduced into water in the vicinity of the proposed spent nuclear fuel storage and examination facilities. The following discussion provides a brief description of the key points associated with obtaining these estimates. All radionuclides which were considered to be introduced into the water at a site were postulated to be promptly distributed uniformly in the water in the immediate vicinity of the site during the time period in which the nuclides were introduced. There are two processes by which radionuclides might enter the water at each site: via liquid discharge or via airborne discharge. For liquid discharges, a fraction of the released radionuclides might enter the water accessed by humans each year by infiltrating the ground to the groundwater then traveling either to wells or surface water. For airborne discharges, some fraction of the released radionuclides might enter the water by deposition from the air. For both of these processes, the fraction of radionuclides that might enter the water used by humans has been postulated to enter the water immediately, except for NRF and the Nevada Test Site. For NRF and the Nevada Test Site, it has been postulated that 20 years pass before the nuclides might enter the water accessed by humans. This estimate is based upon the fact that water must percolate into the ground and reach groundwater resources. Further, contamination must travel with the water in the aquifer to a point where it can be used by humans, such as a well at Atomic City. An assessment of the infiltration rate of radionuclides beneath ICPP estimates that about 200 years are needed for them to pass into the aquifer (Smith 1994). Also, the water in the aquifer flows at a rate of 5 to 20 feet per day. Therefore, 20 years was used as the time for radionuclides to reach humans at INEL. Similarly, at the Nevada Test Site surface water is not present so water must reach aquifers which are more than 600 feet deep. Hence, 20 years was also used at this site.

Once the radionuclides have been introduced into the water at a site, they were calculated to be transported to locations where they might affect man either directly as via immersion (swimming) or indirectly as via ingestion of food. During this transport period, these radionuclides are subjected to various mechanisms which may reduce their concentration in the water such as radioactive decay, dilution in larger volumes of water, removal by sedimentation, etc. The pathways considered in this analysis by which radionuclides in the water at a site might reach man are immersion, exposure to surface deposits, boating and equipment exposure, and consumption of drinking water, fish, crustacea, molluscs, game animals, vegetables and fruits, root crops, milk and eggs, and domesticated animals. During the period when the radionuclides have left the water environment and are being transported through the pathways to man, they may be subjected to both concentration and removal mechanisms which will further modify their effect upon man. These mechanisms include concentration in the surface deposit, animal, and crop pathways; decay during periods between harvesting a crop and its ingestion by man; and removal of activity due to harvesting, handling, and cleaning of a foodstuff.

For each of the sites at which storage or examination of spent nuclear fuel is being considered, estimates were made for the exposures which the total population affected by releases from the site may receive and for the exposures which a maximally exposed individual may receive from these same releases. The exposures to the population affected at a given site were obtained by calculating the exposures received by an average individual in the vicinity of that site and multiplying that exposure by the number of people that are affected. The exposure to a maximally exposed individual used the maximum exposures and consumption rates which any individual at that site may experience regardless of the probabilities associated with just one individual actually following all the maximum pathways. The specific pathways which are applicable at a given site are dependent upon the site, since the exposure of an average or a maximum individual to each of the pathways is different for each of the sites. For example, exposures associated with the drinking water pathway are not considered for the shipyard sites since all radionuclides basically end up in salt water prior to their becoming available to man at these sites. On the other hand, the radionuclides introduced at the DOE and prototype sites can enter the drinking water pathway after a delay period. An initial delay occurs while the radionuclides seep through the ground soil before entering the aquifer. The delay continues while the radionuclides travel through the drinking water pathway and ultimately yield exposures to man. The total exposure to the population or to a maximally exposed individual at a given site is the resultant sum of the exposure commitments from the individual pathways applicable at that site.

F.1.3.7 Categorization of Accidents.

F.1.3.7.1 Abnormal Events. Abnormal Events are unplanned or improper events which result

in little or no consequence. Abnormal events include industrial accidents and accidents during normal operations such as skin contamination with radioactive materials, spills of radioactive liquids, or exposure to direct radiation due to improper placement of shielding. The occurrence of these unplanned events has been anticipated and mitigative procedures are in place which promptly detect and eliminate the events and limit the effects of these events on individuals. As a result, there is little hazard to the general population from these events. Such events are considered to occur in the probability range of 1 to 10-3 per year. The probability referred to here is the total probability of occurrence and includes the probability the event occurs (e.g., plane crash) times other probabilities required for the consequences. For accidents included in this range, results are presented for both the 50% meteorological condition (average meteorology) and the 95% meteorological condition.

F.1.3.7.2 Design Basis Accident Range. Accidents which have a probability of occurrence

in the range of 10-3 to 10-6 per year are included in the range called the Design Basis Accident Range. The terminology "design basis accident," which normally refers to facilities to be constructed, also includes the "evaluation" basis accident which applies to existing facilities. For accidents included in this range, results are presented for both the 50% meteorological condition (average meteorology) and the 95% meteorological condition. Risk calculations for accidents in this range utilize the consequences associated with 95% meteorological conditions.

F.1.3.7.3 Beyond Design Basis Accidents. This range includes accidents which are less

likely to occur than the design basis accidents but which may have very large or catastrophic consequences. Accidents included in this range typically have a total probability of occurrence in the range of 10-6 to 10-7 per year. Accidents which are less likely than 10-7 per year typically are not discussed since it is expected they do not contribute in any substantial way to the risk. For these beyond design basis accidents, consequences are presented for 50% and 95% meteorological conditions. Risk calculations for accidents in this range utilize the consequences associated with 95% meteorological conditions.

F.1.3.8 Evaluation of Impacted Area

The impacted area surrounding a facility following an accident was determined for each scenario evaluated. The impacted area was defined as that area in which the plume deposited radioactive material to such a degree that an individual standing on the boundary of the fallout area would receive approximately 0.01 mrem/hr of exposure. If this individual spends 24 hours a day at this location, that person would receive about 88 mrem per year from the ground surface shine. This is within the 100 mrem/year limit of 10CFR20.

To best characterize the affected areas for each casualty, a typical 50% meteorology was chosen (Pasquill-Gifford Class D, wind speed 10 mph) and applied to each accident scenario. The RSAC-5 results for ground surface dose were interpolated to determine the distance downwind where the centerline dose had dropped to approximately 88 mrem per year based on 24 hours per day exposure. For the wind class chosen, the plume remains within a singe 22.5-degree sector. The area affected by the plume is determined as the entire sector contaminated to the calculated downwind distance. Table F.1.3.8-1 lists each facility accident analyzed and the contaminated footprint associated with the accident.

F.1.3.8-1. Footprint estimates for facility accidents.

Accident Scenario	Footprint Length (miles)	Footprint Area* (acres)	Sites with Footprint Beyond Facility Boundary
Drained Water Pool	0.29	11	Norfolk, Oak Ridge, Portsmouth
Criticality	0.25	8	Norfolk, Oak Ridge, Portsmouth
Wet Storage Mechanical Damage	<0.06	<0.5	none
Wet Storage Airplane Crash	<0.06	<0.5	none
Dry Storage Mechanical Damage	<0.06	<0.5	none
Dry Storage Airplane Crash	0.91	106	Pearl Harbor, Norfolk, Oak Ridge, Portsmouth
Dry Cell Mechanical Damage	<0.06	<0.5	none
HEPA Filter Fire	<0.06	<0.5	none
Dry Cell Airplane Crash	1.27	207	Oak Ridge

*Based on contamination of a single sector.

Although the plume would be contained within a single sector, the direction of the wind is unknown. Therefore, each site was examined for impacts in all directions around the facility site out to a distance equal to the footprint length. Since the accidents do occur over a short duration of time, the acreage of the sector quoted is still an accurate indication of the total contaminated area. Identification of the potential impacts for each site is contained in Tables F.1.3.8-2 through -11.

Table F.1.3.8-2. Secondary impacts of facility accidents at Puget Sound Naval Shipyard.

Site	Significant Accidents in Decreasing Severity	Environmental Contamination	Endangered Species	Biotic Resources	Land Use	Water Resources	Treaty Rights	Economic Impacts	National Defense
Puget Sound Naval Shipyard	1. Dry Storage Plane Crash 2. Drained Water Pool	1. A total of approximately 106 acres might require clean-up. Contamination could extend about 0.6 miles beyond the closest site boundary. 2. Contamination might occur	The facility accident would not result in the extermination of any species. Nor would it effect the long term potential	Plants and animals on the site and around the site will experience no long term impacts	Access to some areas may be temporarily restricted until cleanup is completed. The total area restricted would be no greater than the	The water used for drinking and industrial purposes is monitored and use may be temporarily suspended during cleanup operations.	No enduring	A small number of individuals may experience temporary job loss due to temporary restrictions on farming, fishing and other support activities near the facility	Naval vessels at the shipyard could be temporarily contaminated during the accident. Cleanup operations would restore

up to the nearest shipyard boundary but would be limited to approximately 10 acres total. 3.Contamination would be within the shipyard boundaries. Table F.1.3.8-1 lists the area that could be contaminated.	3. Criticality and all other radiological accidents	for survival of any species. A listing of endangered species can be found in Section 4.1.1 of this Appendix.	impacts. areas identified under "Environmental Contamination".	Some recreational activities may also be temporarily suspended. No enduring impacts are expected.	during cleanup operations. Some costs would also be incurred for the actual cleanup operation.	these ships to full readiness.

Table F.1.3.8-3. Secondary impacts of facility accidents at Pearl Harbor Naval Shipyard.

Site	Environmental Contamination	Significant Accidents in Decreasing Severity	Endangered Species	Biotic Resources	Land Use	Water Resources	Treaty Rights	Economic Impacts	National Defense
Pearl Harbor Naval Shipyard	1. A total of approximately 106 acres might require cleanup. Contamination could extend about 0.4 miles beyond the closest site boundary. 2.	1. Dry Storage Plane Crash 2. All other radiological	The facility accident would not result in the extermination of any species. Nor would it effect the long term potential for survival of any species. A listing of	Plants and animals on the site and around the site will experience no long term impacts	Access to some areas may be temporarily restricted until cleanup is completed. The total area restricted would be no greater than the	The water used for drinking and industrial purposes is monitored and use may be temporarily suspended during cleanup operations. Some	No enduring	A small number of individuals may experience temporary job loss due to temporary restrictions on farming, fishing and other support activities near the facility	Naval vessels at the shipyard could be temporarily contaminated during the accident. Cleanup operations would re-

	accidents	Contamination would be within the shipyard boundaries. Table F.1.3.8-1 lists the areas that could be contaminated.	endangered species can be found in Section 4.1.4 of this Appendix.	impacts.	areas identified under "Environmental Contamination".	recreational activities may also be temporarily suspended. No enduring impacts are expected.		during cleanup operations. Some costs would also be incurred for the actual cleanup operation.	store these ships to full readiness.

Table F.1.3.8-4. Secondary impacts of facility accidents at Norfolk Naval Shipyard.

Site	Accidents in Decreasing Severity	Environmental Contamination	Significant Endangered Species	Biotic Resources	Land Use	Water Resources	Treaty Rights	Economic Impacts	National Defense
Norfolk Naval Shipyard	1. Dry Storage Plane Crash	1. A total of approximately 106 acres might require cleanup. Contamination could extend about 0.8 miles beyond the closest site boundary.	The facility accident would not result in the extermination of any species.	Plants and animals on the site and around the site will experience no long term impacts.	Access to some areas may be temporarily restricted until cleanup is completed.	The water used for drinking and industrial purposes is monitored and use may be temporarily suspended during cleanup operations. Some recreational activities may also be temporarily suspended. No enduring impacts are expected.	No enduring impacts	A small number of individuals may experience temporary job loss due to temporary restrictions on farming, fishing and other support activities near the facility during cleanup operations. Some costs would also be incurred for the actual cleanup operation.	Naval vessels at the shipyard could be temporarily contaminated during the accident. Cleanup operations would restore these ships to full readiness.
	2. Drained Water Pool and Criticality	2. This accident might contaminate about 10 acres which could extend beyond the nearest site boundary by about 0.1 miles	The total Nor would it effect the potential for survival of any species. A listing of endangered species can be found in Section 4.1.2 of this Appendix.		area restrictions would be no greater than the areas identified under "Environmental Contamination."				
	3. All other radiological accidents	3. Contamination would be within the shipyard							

boundaries. Table F.1.3.8-1 lists the areas that could be contaminated.

Table F.1.3.8-5. Secondary impacts of facility accidents at Portsmouth Naval Shipyard.

Site	Significant Accidents in Decreasing Severity	Land Use	Biotic Resources	Water Resources	Endangered Species	Treaty Rights	Economic Impacts	National Defense	Environmental Contamination
Portsmouth Naval Shipyard	1. Dry Storage Plane Crash 2. Drained Water Pool 3. Criticality and all other radiological accidents	Access to some areas may be temporarily restricted until clean-up is completed. The total area restricted would be no greater than the areas identified under "Environmental Consequences".	Plants and animals on the site and around the site will experience no long term impacts.	The water used for drinking and industrial purposes is monitored and use may be temporarily suspended during cleanup operations. Some recreational activities may also be temporarily suspended. No enduring impacts are expected.	The facility accident would not result in the extermination of any species. Nor would it effect the long term potential for survival of any species. A listing of endangered species can be found Section 4.1.3 of this Appendix.	No enduring impacts	A small number of individuals may experience temporary job loss due to temporary restrictions on farming, fishing and other support activities near the facility during cleanup operations. Some costs would also be incurred for the actual cleanup operation.	Naval vessels at the shipyard could be temporarily contaminated during the accident. Cleanup operations would restore these ships to full readiness.	1. A total of approximately 106 acres might require cleanup. Contamination could extend about 0.6 miles beyond the closest site boundary. 2. Contamination might occur up to the nearest shipyard boundary but would be limited to approximately 10 acres total.

3.Contamination would be within the shipyard boundaries. Table F.1.3.8-1 lists the areas that could be contaminated.

Table F.1.3.8-6. Secondary impacts of facility accidents at Oak Ridge Reservation.

Site	Significant Accidents in Decreasing Severity	Environmental Contamination	Endangered Species	Land Use	Biotic Resources	Water Resources	Treaty Rights	Economic Impacts	National Defense
Oak Ridge Reservation	1. Dry Cell Air Plane Crash 2. Dry Storage Plane Crash 3. Drained Water Pool and Criticality 4. All other radiological accidents	1. A total of approximately 207 acres might require cleanup. Contamination could extend about 1.1 miles beyond the closest site boundary. 2. This accident could contaminate about 106 acres and would extend beyond the nearest site boundary by about 0.7 miles. 3. About 10 acres might become contaminated extending about 0.1 miles offsite. 4.Contamination	The facility accident would not result in the extermination of any species. Nor would it effect the long term potential for survival of any species. A listing of endangered species can be found in Section 4.5 of this Appendix.	Access to some areas may be temporarily restricted until cleanup is completed. The total area restricted would be no greater than the areas identified under "Environmental Consequences".	Plants and animals on the site and around the site will experience no long term impacts.	The water used for drinking and industrial purposes is monitored and use may be temporarily suspended during cleanup operations. Some recreational activities may also be temporarily suspended. No enduring impacts are expected.	Some temporary restrictions on access may be required until cleanup is completed. No enduring impacts are expected.	A small number of individuals may experience temporary job loss due to temporary restrictions on farming, fishing and other support activities near the facility during cleanup operations. Some costs would also be incurred for the actual cleanup operation.	No impacts

would remain within the site boundaries. Table F.1.3.8-1 lists the areas that could be contaminated.

Table F.1.3.8-7. Secondary impacts of facility accidents at Savannah River Site.

Site	Significant Accidents in Decreasing Severity	Environmental Contamination	Endangered Species	Land Use	Biotic Resources	Water Resources	Treaty Rights	Economic Impacts	National Defense
Savannah River Site	All Radiological Accidents	Contamination would remain within the site boundaries. Table F.1.3.8-1 lists the areas that could be contaminated.	The facility accident would not result in the extermination of any species. Nor would it effect the long term potential for survival of any species. A listing of endangered species can be found in Section 4.3 of this Appendix.	Access to some areas may be temporarily restricted until cleanup is completed. No enduring impacts are expected.	Plants and animals on the site and around the site will experience no long term impacts.	The water used for drinking and industrial purposes is monitored and use may be temporarily suspended during cleanup operations. Some recreational activities may also be temporarily suspended. No enduring impacts are expected.	Some temporary restrictions on access may be required until cleanup is completed.	A small number of individuals may experience temporary job loss due to temporary restrictions on farming, fishing and other support activities near the facility during cleanup operations. Some costs would also be incurred for the actual cleanup operation.	No impacts

Table F.1.3.8-8. Secondary impacts of facility accidents at Nevada Test Site.

Site	Significant Accidents in Decreasing Severity	Environmental Contamination	Endangered Species	Land Use	Biotic Resources	Water Resources	Treaty Rights	Economic Impacts	National Defense
								A small number of	

Nevada Test Site	All Radiological Accidents	Contamination would remain within the site boundaries. Table F.1.3.8-1 lists the areas that could be contami-nated.	The facility accident would not result in the exterminatio n of any spe-cies. Nor would it effect the long term potential for survival of any species. A listing of endangered species can be found Section 4.6 of this Appendix.	Access to some areas may be temporaril y restricted until clean-up is completed. Some enduring impacts are expected.	Plants and animals on the site and around the site will experience no long term impacts.	The water used for drinking and industrial purposes is monitored and use may be temporari-ly suspended during cleanup operations. No enduring impacts are expected.	temporary restrictions on access may be required until cleanup is completed. No	individuals may experience temporary job loss due to temporary restrictions on support activities near the facility during cleanup operations. Some costs would also be incurred for the actual cleanup operation.	No impacts

Table F.1.3.8-9. Secondary impacts of facility accidents at Idaho National Engineering Laboratory.

Site	Significant Accidents in Decreasing Severity	Environmental Contamination	Endangered Species	Land Use	Biotic Resources	Water Resources	Treaty Rights	Economic Impacts	National Defense
Idaho National Engineering Laboratory	All Radiological Accidents	Contamination would remain within the site boundaries. Table F.1.3.8-1 lists the areas that could be contami-nated.	The facility accident would not result in the exterminatio n of any species. Nor would it effect the long term potential for survival of	Access to some areas may be temporaril y restricted until cleanup is completed. Some	Plants and animals on the site and around the site will experience no long	The water used for drinking and industrial purposes is monitored and use may be temporari-ly suspended during cleanup operations.	temporary restrictions on access may be required until cleanup is completed. No	A small number of individuals may experience temporary job loss due to temporary restrictions on support activities near the facility during cleanup	No impacts

			any species. A listing of endangered species can be found Section 4.2 of this Appendix.	enduring impacts are expected.	term impacts.	No enduring impacts are expected.		operations. Some costs would also be incurred for the actual cleanup operation.	

Table F.1.3.8-10. Secondary impacts of facility accidents at Hanford Site.

Site	Significant Accidents in Decreasing Severity	Environmental Contamination	Endangered Species	Land Use	Biotic Resources	Water Resources	Treaty Rights	Economic Impacts	National Defense
Hanford Site	All Radiological Accidents	Contamination would remain within the site boundaries. Table F.1.3.8-1 lists the areas that could be contaminated.	The facility accident would not result in the extermination of any species. Nor would it effect the long term potential for survival of any species. A listing of endangered species can be found Section 4.4 of this Appendix.	Access to some areas may be temporarily restricted until cleanup is completed. No enduring impacts are expected.	Plants and animals on the site and around the site will experience no long term impacts.	The water used for drinking and industrial purposes is monitored and may be temporarily suspended during cleanup operations. Some recreational activities may also be temporarily suspended. No enduring impacts are expected.	Some temporary restrictions on access may be required until cleanup is completed.	A small number of individuals may experience temporary job loss due to temporary restrictions on support activities near the facility during cleanup operations. Some costs would also be incurred for the actual cleanup operation.	No impacts

Table F.1.3.8-11. Secondary impacts of facility accidents at Kenneth A. Kesselring Site.

Site	Significant Accidents in	Environmental Contamination	Endangered Species	Land Use	Biotic Resources	Water Resources	Treaty Rights	Economic Impacts	National Defense

	Decreasing Severity							
	1. Dry Storage Plane Crash 2. Drained Water Pool and all other radiological accidents	1. Contamination is expected right up to the nearest site boundary but limited to approximately 106 acres total. 2.Contamination would remain within the shipyard boundaries. Table F.1.3.8-1 lists the areas that could be contaminated.	The facility accident would not result in the exterminatio n of any species. Nor would it effect the long term potential for survival of any species. A listing of endangered species can be found Section 4.1.5 of this Appendix.	Access to some areas may be tempoarily restricted until cleanup is completed.	Plants and animals on the site and around the site will experience no long term impacts.	The water used for drinking and industrial purposes is monitored and use may be temporarily suspended during cleanup operations. Some recreational activities may also be temporarily suspended. No enduring impacts are expected.	A small number of individuals may experience temporary job loss due to temporary restrictions on support activities near the facility during cleanup operations. Some costs would also be incurred for the actual cleanup operation.	
Kenneth A. Kesselring Site						Some temporary restriction s on access may be required until cleanup is completed. No enduring impacts are expected.		No impacts

F.1.3.9 Emergency Preparedness and Mitigative Measures.

F.1.3.9.1 Emergency Preparedness Emergency plans are in effect at shipyards and

prototype sites to ensure that workers and the public would be properly protected in the event of an accident. In addition, emergency plans are in effect for accidents involving the transportation of radioactive materials. These response plans include the activation of emergency response teams provided by the site and a site emergency control center, as well as activation of a command and control network with Naval Reactors Headquarters and supporting laboratories. The long standing emergency planning program that exists within the Naval Nuclear Propulsion Program includes the ability to utilize the comprehensive and extensive emergency response resources of each naval site and provides for coordination with appropriate civil authorities. In addition to the Naval Nuclear Propulsion Program resources, extensive federal emergency response resources are available as needed to support State or local response.

Emergency response measures include provisions for immediate response to any emergency at the shipyard or prototype site, identification of the accident conditions, and communications with civil authorities providing radiological data and recommendations for any appropriate protective actions. In the event of an accident involving radioactive or toxic materials, workers in the vicinity of the accident would promptly evacuate the immediate area. This evacuation can typically be accomplished within minutes of the accident and would reduce the hazard to workers.

Regularly scheduled exercises are conducted periodically at each site in order to test each site's ability to respond to accidents. These exercises include realistic tests of people, equipment, and communications involved in all aspects of the plans, and the plans are regularly reviewed and modified to incorporate experience gained from the exercises. These exercises also periodically include steps to verify the adequacy of interactions with local hospitals and emergency personnel and state officials.

F.1.3.9.2 Mitigative Factors. For members of the general public residing at the site boundary

or beyond, no credit is taken for any preventive or mitigative actions that would limit their exposure. These individuals are calculated as being exposed to the entire contaminated plume as it travels downwind from the accident site. Similarly no action is taken to prevent these people from continuing their normal day-to-day routine and ingestion of terrestrial food and animal products continue on a yearly basis. As discussed in Section F.1.3, action would be taken to prevent the public from exceeding a Protective Action Guideline, if needed. No reduction of exposure due to these actions are accounted for in this analysis. The public is assumed to spend approximately 30% of the day within their homes or other buildings and the exposure to ground surface radiation is therefore reduced appropriately on a yearly basis.

Individuals that reside or work on site, or those that may be traversing the site in a vehicle would be evacuated from the affected area within 2 hours. This is based on the availability of security personnel at all locations to oversee the removal of residents, collocated workers, and travelers in a safe and efficient manner. Periodic training and evaluation of the security personnel is conducted to ensure that correct actions are taken during an actual casualty. Therefore, residents, collocated workers, and travelers would be exposed to the entire contaminated plume as it travels downwind for a period not to exceed 2 hours. Similarly, the radiation shine from the deposited radioactive materials would be limited to a 2-hour period. No ingestion of contamination is calculated for these individuals.

Facility workers all undergo training to take quick, decisive action during a casualty. These individuals quickly evacuate the area and move to previously defined "relocation" areas on the facility site. Workers could be exposed to a full 5 minutes of the radioactive plume as they move to the "relocation" centers. Once the immediate threat of the plume has moved off-site and downwind, the workers would be instructed to walk to vehicles waiting to evacuate them from the site. An additional 15 minutes would be required to evacuate the workers from the contaminated area and therefore the workers receive a total of 20 minutes of ground shine. No ingestion of contamination is calculated for these individuals.

The following summary provides the individual exposure times utilized in the accident analyses presented in Section F.1.4.2.

Estimated Time an Individual Might be Exposed

	Worker (100 m)	Collocated Worker (MCW) and Nearest Public Access (NPA)	Individual at Nearest Site Boundary (MOI)
To Plume	5 min.	100% of release time up to 120 min.	100% of release time

To Fallout on Ground Surface	20 min.	120 min.	0.7 yr
To Food	N/A	N/A	1 yr

F.1.3.10 Perspective on Calculations of Cancer Fatalities and Risk

The topics of human health effects caused by radiation and the risks associated with normal operations or postulated accidents associated with spent nuclear fuel management are discussed many times throughout this Environmental Impact Statement. It is important to understand these concepts and how they are used in order to understand the information presented in this document. It is also valuable to have some frame of reference or comparison for understanding how the risks compare to the risks of daily life.

The method used to calculate the risk of any impact is fundamental to all of the evaluations presented and follows standard accepted practices. The first step is to determine the probability that a specific event will occur. For example, the probability that a routine task, such as operating a crane, will be performed sometime during a year of normal operations at a facility would be 1. That means that the action would certainly occur. The probability that an accident might occur is less than 1.0. This is true because accidents occur only occasionally and some of the more severe accidents, such as a catastrophic earthquake, might occur at any location only once in hundreds, thousands, or millions of years.

Once the probability of an event has been determined, the next step is to predict what the consequences of the event being considered might be. One important measure of consequences chosen for this EIS is the number of human fatalities from cancer induced by radiation. This was chosen because this document deals with radioactive materials. The number of cancer fatalities that might be caused by any routine operation or any postulated accident can be calculated using a standard technique based on the amount of radiation exposure that might occur from all conceivable pathways and the number of people who might be affected (refer to Section F.1.3.3).

A couple of examples should serve to illustrate the calculation of risk. In the first, the lifetime risk of dying in a motor vehicle accident can be computed from the likelihood of an individual being in an automobile accident and the consequences or number of fatalities per accident. There were 10,000,000 motor vehicle accidents during 1992 in the United States resulting in about 40,000 deaths (NSC 1993). Thus, the probability of a person being in an automobile accident is 10,000,000 accidents divided by approximately 250,000,000 persons in the United States, or 0.04 per year. The number of fatalities per accident, 0.004 (40,000 deaths divided by 10,000,000 accidents), is less than 1 since many accidents do not cause fatalities. Multiplying the probability of the accident (0.04 per year) by the consequences of the accident (0.004 deaths per accident) by the number of years the person is exposed to the risk (72 years is considered to be an average lifetime) gives the risk for any individual being killed in an automobile accident. From this calculation, the overall risk of someone dying in a motor vehicle accident is about 1 chance in 87 over their lifetime.

A second example illustrates the calculation of risk for another event which occurs daily. Fossil fuels, such as natural gas or coal, contain naturally occurring radioactive material that is released into the air during combustion. This radioactivity in the air finds its way into our bodies through our food and the air we breathe. This radioactivity has been estimated to produce about 0.5 millirem of radiation dose to the average American each year (NCRP 1987). The probability of this happening is essentially 1.0 since these fuels are burned every day all over the country. The number of fatal cancers from exposure to 0.5

millirem per year is calculated by taking 0.5 millirem per year times the 72 years considered to be an average lifetime times the 0.0005 fatal cancers estimated to be caused by each rem (0.5 millirem per year x 72 years x 0.0005 fatal cancers per rem = 0.000018 fatal cancers per individual lifetime). The risk is the probability (1.0) times the consequences (0.000018 cancer fatalities) which equals about 1 chance in 55,000 of death from this cause over a lifetime.

These risks and others from everyday life can be used to gain a perspective on the risks associated with the alternatives in this EIS. As illustrated, the risk of death from cancer from the radioactivity released daily from combustion of fossil fuels is about 1 chance in 55,000 for the average American. As a further comparison, the naturally occurring radioactive materials in agricultural fertilizer contribute about 1 to 2 millirem per year to an average American's exposure to radiation (NCRP 1987). A calculation similar to the one in the preceding paragraph shows that the use of fertilizer to produce food crops in the United States results in a risk of death from cancer between 1 chance in 12,500 and 1 chance in 25,000. Finally, the average American's risk of dying from cancer from all causes is 1 chance in 5 over his or her lifetime. These risks can be compared, for example, to the average individual risk of less than 1 chance in 1 billion for a resident in the vicinity of the INEL developing a fatal cancer due to normal operations at the Expended Core Facility (see the data in Section F.1.4.1).

A frame of reference for the risks from accidents associated with spent nuclear fuel management alternatives can be developed in the same way. For an average resident in the vicinity of the INEL, the individual risk of death from cancer caused by the water leaking from the Expended Core Facility after a large earthquake would be approximately 1 chance in 9 billion. This individual risk was determined by dividing the risk value to the population within 50 miles (1.7 x 10-7 fatalities per year per accident from Table F-3) by the total population of 115,690 and multiplying by an average life span of 72 years. This risk can be compared to the risks of death from other accidental causes to gain a perspective. For example, the risk of death in a motor vehicle accident was calculated earlier to be about 1 chance in 87. Similarly, the risk of death for the average American from fires is approximately 1 chance in 500, and for death from accidental poisoning the risk is about 1 chance in 1000 (Crouch 1982).

F.1.4 Analysis Results

F.1.4.1 Normal Operations. The purpose of this analysis is to determine the hypothetical health effects on workers and the public due to routine handling of naval spent nuclear fuel. Radioactive releases from facilities involved in routine handling of naval spent nuclear fuel are small and less than those of comparable DOE and commercial nuclear facilities. Records of routine releases due to operations at ECF were used as source terms for all locations to estimate what effects these types of releases have on workers and the public. Site-specific meteorological and population data were used at each of the locations analyzed. For normal operations at the Naval Reactors Facility (NRF and Oak Ridge), exposure to the nearest public access (NPA) individual is not estimated due to the short period of time that such an individual would spend on-site while driving on the public access road. At Hanford, the NPA is located at the Washington Public Power Supply System Plant, and at Savannah River at the U.S. Forestry Service Office. The NPA at shipyard locations is defined in Section F.1.3.2.

F.1.4.1.1 Water Pool Examination and Storage Source Terms. The evaluation of normal water pool operations was performed using two different source terms. In one analysis, a source term was utilized which included both the incremental release of radioactive materials due to the alternative spent nuclear fuel storage actions and the release from other ongoing Naval Reactors activities. Identical source terms were used for the evaluation of radiation exposure due to the release of radioactive materials during normal operations of wet storage and spent fuel examinations. The 1991 annual airborne release from the INEL-ECF was used to evaluate these operations. Since the INEL-ECF releases are extremely low, this upper limit approach is not unduly conservative for the wet storage option which is expected to have a lower release. Table F.1.4.1.1-1 shows the 1991 INEL-ECF release rate, the current release rate at Kesselring and NRF (including both INEL-ECF and prototypes), and the release rate representing Naval Reactors operations at naval shipyards. The release rate representing naval shipyards is based on upper bound data from Navy operations contained in Naval Nuclear Propulsion Program (NNPP) Report NT-94-1 (NNPP 1994). With no current Naval Reactors facilities at Savannah River, Hanford, Oak Ridge, or the Nevada Test Site, the current release for each of these sites is zero for this analysis.

Table F.1.4.1.1-1. Airborne releases from current Naval Reactors operations.

Location	Annual Releases (Ci/year)	
INEL-ECF	H-3 9.35 x 10-2	Y-90 5.5 x 10-6
	C-14 7.0 x 10-1	I-131 4.82 x 10-6
	Sr-90 5.5 x 10-6	Kr-85 3.0 x 10-1
NRF	H-3 9.35 x 10-2	Sr-90 2.45 x 10-5
	C-14 8.0 x 10-1	Y-90 2.45 x 10-5
	Ar-41 2.7 x 10-1	I-131 6.3 x 10-6
	Co-60 1.6 x 10-6	Cs-137 6.3 x 10-6
	Kr-85 3.0 x 10-1	
Kesselring	H-3 1.0 x 10-1	Kr-85 1.0 x 10-3
	C-14 4.0 x 10-1	I-131 5.0 x 10-4
	Ar-41 1.4	Cs-137 5.0 x 10-4
	Co-60 1.0 x 10-3	
Savannah River, Hanford, Nevada Test Site, Oak Ridge	none	
Portsmouth, Norfolk Puget Sound, Pearl Harbor	H-3 1.0 x 10-3	Kr-87 5.0 x 10-2
	C-14 1.0 x 10-1	Kr-88 2.0 x 10-2
	Ar-41 4.1 x 10-1	Xe131m 5.0 x 10-3
	Co-60 1.0 x 10-3	Xe133m 1.0 x 10-2
	Kr-83m 2.0 x 10-2	Xe-133 2.1 x 10-1
	Kr-85m 2.4 x 10-2	Xe-135 2.5 x 10-1
	Kr-85 1.0 x 10-3	

The evaluation of continuing Naval Reactors activities combined with the proposed alternatives for naval spent nuclear fuel is based on the combined airborne release source terms shown in Table F.1.4.1.1-2. This table presents a summation of the INEL-ECF source term and the current Naval Reactors operations source terms from Table F.1.4.1.1-1 for each location. Beginning in 1995, with the shutdown of the S5G prototype, the NRF releases will only result from the INEL-ECF, and this condition is shown in the table.

The other analysis utilized the same source term at all locations. The INEL-ECF source term of Table F.1.4.1.1-1 was used to compare the incremental health effects due to providing water pool storage or examination facilities at each location.

Both analyses also considered the impact on health effects of direct radiation levels from a water pool facility and the deposition of radionuclides onto the ground and into water supplies as discussed in Sections F.1.3.6.4 and F.1.3.6.5.

Table F.1.4.1.1-2. Airborne releases used in the analysis of water pool activities plus ongoing Naval Reactors operations.

Location	Annual Releases (Ci/year)	
NRF, Savannah River, Hanford, Nevada Test Site, OakRidge	H-3 9.35 x 10-2	Y-90 5.5 x 10-6
	C-14 7.0 x 10-1	I-131 4.82 x 10-6
	Sr-90 5.5 x 10-6	Kr-85 3.0 x 10-1
Kesselring	H-3 1.935 x 10-1	Sr-90 5.5 x 10-6
	C-14 1.1	Y-90 5.5 x 10-6
	Ar-41 1.4	I-131 5.0 x 10-4
	Kr-85 3.0 x 10-1	Cs-137 5.0 x 10-4
	Co-60 1.0 x 10-3	

Portsmouth, Norfolk Puget Sound, Pearl Harbor	H-3 9.45 x 10-2	Kr-88 2.0 x 10-2
	C-14 8.0 x 10-1	Sr-90 5.5 x 10-6
	Ar-41 4.1 x 10-1	Y-90 5.5 x 10-6
	Co-60 1.0 x 10-3	I-131 4.8 x 10-6
	Kr-83m 2.0 x 10-2	Xe131m 5.0 x 10-3
	Kr-85m 2.4 x 10-2	Xe133m 1.0 x 10-2
	Kr-85 3.0 x 10-1	Xe-133 2.1 x 10-1
	Kr-87 5.0 x 10-2	Xe-135 2.5 x 10-1

F.1.4.1.2 Dry Storage Source Terms. Another operation analyzed was the storage of naval

spent nuclear fuel in shipping containers or storage casks in a safe array at NRF, the naval shipyards, and Kesselring locations. It is postulated that shielding and physical boundaries are established in accordance with existing regulations to protect facility workers. There are expected to be no routine airborne or water releases from the dry storage activity. The source will consist of an array of filled storage containers. Supplementary shielding would be provided as needed to ensure that there would be no measurable increase in radiation levels at the perimeter of the industrial area and that radiation levels within the industrial area but outside the storage area would not require occupational radiation exposure monitoring for workers. Each location analyzed would have a different number of storage casks. As containers are received over time, shielding will be provided to limit radiation exposure rates as discussed above. Distance falloff for radiation levels was determined using SPAN computer calculations as discussed in Section F.1.3.6.4.

F.1.4.1.3 Dry Cell Facility Source Terms. The normal airborne release source terms

utilized for the dry cell facility analyses are identical to the INEL-ECF releases in Table F.1.4.1-1. It is expected that these values bound the actual releases from the proposed facility. A source term different from the water pool analysis was utilized for the direct radiation calculations. This source term is based on the proposed facility design, expected fuel examination capacity, and shielding calculations. Like the airborne releases, source terms for water deposition were identical to those utilized in the water pool analysis.

F.1.4.1.4 Water Pool Storage. This section presents tabulated radiation exposure results for

the wet storage option. The following summary provides an indication of the incremental change at each location due to the addition of an ECF-type facility.

Summary of Exposure Calculation Results
For Normal Operations - Water Pool Examination or Storage only
At All Sites

	INEL/NRF	Savannah River	Hanford	Puget Sound	Pearl Harbor
Worker EDE (rem)	7.1 x 10-5	9.1 x 10-5	8.9 x 10-5	9.4 x 10-5	1.1 x 10-4
MOI EDE (rem)	2.5 x 10-7	4.8 x 10-7 3.8 x 10-6*	2.4 x 10-7 4.4 x 10-7**	8.7 x 10-5	2.0 x 10-5
NPA EDE (rem)	N/A	2.1 x 10-8	1.3 x 10-8	6.2 x 10-4	5.2 x 10-4
Total EDE (person-rem)	1.7 x 10-3	3.6 x 10-2	8.0 x 10-3	1.3 x 10-1	1.4 x 10-1
Number of Fatal Cancers	8.5 x 10-7	1.8 x 10-5	4.0 x 10-6	6.5 x 10-5	7.0 x 10-5

* MOI (Barnwell Plant)
** MOI (FMEF)

	Norfolk	Portsmouth	Kesselring	Nevada Test Site	Oak Ridge
Worker EDE (rem)	6.9 x 10-5	7.7 x 10-5	8.5 x 10-5	4.6 x 10-5	1.2 x 10-4
MOI EDE (rem)	1.1 x 10-4	4.4 x 10-5	6.8 x 10-6	3.4 x 10-7	1.0 x 10-4
NPA EDE (rem)	6.8 x 10-5	3.3 x 10-4	N/A	N/A	N/A
Total EDE (person-rem)	2.8 x 10-1	4.5 x 10-2	8.2 x 10-2	1.8 x 10-4	1.0 x 10-1
Number of Fatal Cancers	1.4 x 10-4	2.3 x 10-5	4.1 x 10-5	9.0 x 10-8	5.0 x 10-5

Evaluations of environmental impacts at DOE sites are presented in Volume 1, Appendices A, B, C, and F. The radiological impacts at these sites are quite low in that fatal cancer projections to the population within 50 miles from normal operations are well below 1.0. Further, impacts at naval shipyards and prototype sites are addressed in Appendix D and also are well below 1.0. Hence, the addition of the above small values to those which already exist at a site result in total values which are also quite small.

The following summary provides the exposure calculation results for water pool storage or examination plus all ongoing Naval Reactors operations at each site.

Summary of Exposure Calculation Results
For Normal Operations - Water Pool Examination or Storage
plus all ongoing Naval Reactors operations
At all sites

	INEL/NRF	Savannah River	Hanford	Puget Sound	Pearl Harbor
Worker EDE (rem)	7.1 x 10-5	9.1 x 10-5	8.9 x 10-5	1.2 x 10-4	1.4 x 10-4
MOI EDE (rem)	2.5 x 10-7	4.8 x 10-7 3.8 x 10-6*	2.4 x 10-7 4.4 x 10-7**	1.0 x 10-4	2.3 x 10-5
NPA EDE (rem)	N/A	2.1 x 10-8	1.3 x 10-8	7.2 x 10-4	5.8 x 10-4
Total EDE (person-rem)	1.7 x 10-3	3.6 x 10-2	8.0 x 10-3	1.5 x 10-1	1.7 x 10-1
Number of Fatal Cancers	8.5 x 10-7	1.8 x 10-5	4.0 x 10-6	7.6 x 10-5	8.5 x 10-5

* MOI (Barnwell Plant)
** MOI (FMEF)

	Norfolk	Portsmouth	Kesselring	Nevada Test Site	Oak Ridge
Worker EDE (rem)	8.4 x 10-5	9.7 x 10-5	1.4 x 10-4	4.6 x 10-5	1.2 x 10-4
MOI EDE (rem)	1.2 x 10-4	5.0 x 10-5	1.2 x 10-5	3.4 x 10-7	1.0 x 10-4
NPA EDE (rem)	7.4 x 10-5	3.5 x 10-4	N/A	N/A	N/A
Total EDE (person-rem)	3.4 x 10-1	5.5 x 10-2	1.4 x 10-1	1.8 x 10-4	1.0 x 10-1
Number of Fatal Cancers	1.7 x 10-4	2.7 x 10-5	7.2 x 10-5	9.0 x 10-8	5.0 x 10-5

Tables F.1.4.1.4-1 through -10 present the detailed results of using the source terms of Table F.1.4.1-2 to determine the radiation exposures. These tables thus depict the result if an ECF-type examination operation is added to existing, current, continuing Naval Reactors operations at DOE sites and Navy shipyards.

Table F.1.4.1.4-1. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Examination plus all ongoing Naval Reactors operations
At INEL

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.1 x 10-5	2.8 x 10-8
MCW	4.2 x 10-8	1.7 x 10-11
MOI	2.5 x 10-7	1.3 x 10-10

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115,690	1.7 x 10-3	8.5 x 10-7

Table F.1.4.1.4-2. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Examination plus all ongoing Naval Reactors operations
At Savannah River

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	9.1 x 10-5	3.6 x 10-8
MCW	1.4 x 10-6	5.6 x 10-10
MOI (New ECF)*	4.8 x 10-7	2.4 x 10-10
MOI (Barnwell Plant)	3.8 x 10-6	1.9 x 10-9
NPA	2.1 x 10-8	1.1 x 10-11

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579,541	3.6 x 10-2	1.8 x 10-5

* MOI (New ECF) applies if spent fuel facility is constructed on the Savannah River Site.

**MOI (Barnwell Plant) applies if spent fuel facility is constructed at Barnwell Nuclear Fuel Plant.

Table F.1.4.1.4-3. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Examination plus all ongoing Naval Reactors operations
At Hanford

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.9 x 10-5	3.6 x 10-8
MCW	1.6 x 10-6	6.4 x 10-10
MOI (New ECF)*	2.4 x 10-7	1.2 x 10-10
MOI (FMEF)**	4.4 x 10-7	2.2 x 10-10
NPA	1.3 x 10-8	6.5 x 10-12

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375,860	8.0 x 10-3	4.0 x 10-6

* MOI (New ECF) applies if spent fuel facility is constructed at the 200 area on the Hanford Site.

**MOI (FMEF) applies if spent fuel facility is constructed at the Fuels and Materials Examination Facility.

Table F.1.4.1.4-4. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Storage plus all ongoing Naval Reactors operations
At Puget Sound

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.2 x 10-4	4.8 x 10-8
MOI	1.0 x 10-4	5.1 x 10-8
NPA	7.2 x 10-4	3.6 x 10-7

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2,975,810	1.5 x 10-1	7.6 x 10-5

Table F.1.4.1.4-5. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Storage plus all ongoing Naval Reactors operations
At Pearl Harbor

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.4 x 10-4	5.6 x 10-8
MOI	2.3 x 10-5	1.1 x 10-8
NPA	5.8 x 10-4	2.9 x 10-7

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817,385	1.7 x 10-1	8.5 x 10-5

Table F.1.4.1.4-6. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Storage plus all ongoing Naval Reactors operations
At Norfolk

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.4 x 10-5	3.4 x 10-8
MOI	1.2 x 10-4	6.1 x 10-8
NPA	7.4 x 10-5	3.7 x 10-8

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1,539,002	3.4 x 10-1	1.7 x 10-4

Table F.1.4.1.4-7. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Storage plus all ongoing Naval Reactors operations
At Portsmouth

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	9.7 x 10-5	3.9 x 10-8
MOI	5.0 x 10-5	2.5 x 10-8
NPA	3.5 x 10-4	1.7 x 10-7

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2,432,627	5.5 x 10-2	2.7 x 10-5

Table F.1.4.1.4-8. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Storage plus all ongoing Naval Reactors operations
At Kesselring

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.4 x 10-4	5.6 x 10-8
MOI	1.2 x 10-5	5.8 x 10-9

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1,148,587	1.4 x 10-1	7.2 x 10-5

Table F.1.4.1.4-9. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Examination plus all ongoing Naval Reactors operations
At Nevada Test Site

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	4.6 x 10-5	1.8 x 10-8
MCW	3.7 x 10-9	1.5 x 10-12
MOI	3.4 x 10-7	1.7 x 10-10

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13,792	1.8 x 10-4	9.0 x 10-8

Table F.1.4.1.4-10. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Examination plus all ongoing Naval Reactors operations
At Oak Ridge

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.2 x 10-4	4.8 x 10-8
MCW	1.3 x 10-7	5.1 x 10-11
MOI	1.0 x 10-4	5.1 x 10-8

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers

Population of 871,531	1.0 x 10-1	5.0 x 10-5

F.1.4.1.5 Dry Storage. This section presents tabulated radiation exposure results for the dry storage option at INEL, Navy shipyard sites, and the Kesselring Site. Dry storage at Hanford, Savannah River, the Nevada Test Site, and Oak Ridge is not included in this section as it is discussed in EIS Volume 1, Appendices A, C, and F, respectively. The following summary provides an indication of the incremental change at each location due to the addition of dry storage areas. The health effect due to dry storage of spent fuel is largest at the Navy shipyards and is extremely small at all DOE locations.

Summary of Exposure Calculation Results
For Normal Operations - Dry Storage only
At all sites

	INEL	Puget Sound	Pearl Harbor	Norfolk	Portsmouth	Kesselring
Worker EDE (rem)	1.1 x 10-2	5.4 x 10-3	2.1 x 10-3	5.8 x 10-3	2.7 x 10-3	6.1 x 10-4
MOI EDE (rem)	6.5 x 10-1	8.9 x 10-5	1.5 x 10-6	2.9 x 10-3	5.6 x 10-5	5.2 x 10-11
NPA EDE (rem)	N/A	7.4 x 10-3	2.3 x 10-2	2.9 x 10-3	2.2 x 10-2	N/A
Total EDE (person-rem)	1.7 x 10-1	2.4 x 10-3	1.9 x 10-5	4.3 x 10-2	4.6 x 10-4	8.2 x 10-9
Number of Fatal Cancers	8.6 x 10-1	1.2 x 10-6	9.3 x 10-9	2.1 x 10-5	2.3 x 10-7	4.1 x 10-12

Tables F.1.4.1.5-1 through -6 present the results if a dry storage area is added to existing, current, continuing Naval Reactors operations at all locations.

Table F.1.4.1.5-1. Summary of Exposure Calculation Results.
For Normal Operations - Dry Storage plus all ongoing Naval Reactors operations
At INEL

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.1 x 10-2	4.4 x 10-6
MOI	1.1 x 10-10	5.5 x 10-14
NPA	6.5 x 10-14	3.3 x 10-17

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115,690	1.7 x 10-12	8.6 x 10-16

Table F.1.4.1.5-2. Summary of Exposure Calculation Results.
For Normal Operations - Dry Storage plus all ongoing Naval Reactors operations
At Puget Sound

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.4 x 10-3	2.2 x 10-6
MOI	1.1 x 10-4	5.3 x 10-8
NPA	7.5 x 10-3	3.8 x 10-6

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2,975,810	3.6 x 10-2	1.8 x 10-5

Table F.1.4.1.5-3. Summary of Exposure Calculation Results.
For Normal Operations - Dry Storage plus all ongoing Naval Reactors operations
At Pearl Harbor

Likelihood

Location	Total EDE (rem)	of Fatal Cancer
Worker	2.1 x 10-3	8.5 x 10-7
MOI	5.3 x 10-6	2.7 x 10-9
NPA	2.3 x 10-2	1.2 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817,385	3.3 x 10-2	1.7 x 10-5

Table F.1.4.1.5-4. Summary of Exposure Calculation Results.
For Normal Operations - Dry Storage plus all ongoing Naval Reactors operations
At Norfolk

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.8 x 10-3	2.3 x 10-6
MOI	2.9 x 10-3	1.5 x 10-6
NPA	2.9 x 10-3	1.5 x 10-6
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1,539,002	9.7 x 10-2	4.9 x 10-5

Table F.1.4.1.5-5. Summary of Exposure Calculation Results.
For Normal Operations - Dry Storage plus all ongoing Naval Reactors operations
At Portsmouth

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.7 x 10-3	1.1 x 10-6
MOI	6.3 x 10-5	3.1 x 10-8
NPA	2.2 x 10-2	1.1 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2,432,627	9.2 x 10-3	4.6 x 10-6

Table F.1.4.1.5-6. Summary of Exposure Calculation Results.
For Normal Operations - Dry Storage plus all ongoing Naval Reactors operations
At Kesselring

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	6.6 x 10-4	2.7 x 10-7
MOI	5.1 x 10-6	2.6 x 10-9
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1,148,587	5.7 x 10-2	2.9 x 10-5

F.1.4.1.6 Dry Cell Operations. This section presents tabulated radiation exposure results for the dry cell operations option. Since a facility like the proposed dry cell would only be constructed for the alternatives which include examination of all naval spent fuel, this analysis was only performed for the INEL, Savannah River, Hanford, the Nevada Test Site, and Oak Ridge locations. The following summary provides an indication of the incremental change at each location due to the addition of a dry cell facility.

The calculated health effect to the general population is roughly proportional to the surrounding population with Oak Ridge being the worst and Nevada Test Site being the best.

Summary of Exposure Calculation Results
For Normal Operations - Dry Cell Operations
At all sites

	INEL/NRF	Savannah River	Hanford	Nevada Test Site	Oak Ridge
Worker EDE (rem)	6.3 x 10-5	8.3 x 10-5	8.1 x 10-5	3.5 x 10-5	1.1 x 10-4
MOI EDE (rem)	2.5 x 10-7	4.8 x 10-7 3.8 x 10-6*	2.4 x 10-7 4.4 x 10-7**	3.4 x 10-7	8.9 x 10-5
NPA EDE (rem)	N/A	2.1 x 10-8	1.3 x 10-8	N/A	N/A
Total EDE (person-rem)	1.7 x 10-3	3.6 x 10-2	8.0 x 10-3	1.8 x 10-4	1.0 x 10-1
Number of Fatal Cancers	8.5 x 10-7	1.8 x 10-5	4.0 x 10-6	9.0 x 10-8	5.0 x 10-5

* MOI (Barnwell Plant)
** MOI (FMEF)

Tables F.1.4.1.6-1 through -5 present the detailed analysis results.

Table F.1.4.1.6-1. Summary of Exposure Calculation Results.
For Normal Operations - Dry Cell Operations
At INEL

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	6.3 x 10-5	2.5 x 10-8
MCW	4.2 x 10-8	1.7 x 10-11
MOI	2.5 x 10-7	1.3 x 10-10

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115,690	1.7 x 10-3	8.5 x 10-7

Table F.1.4.1.6-2. Summary of Exposure Calculation Results.
For Normal Operations - Dry Cell Operations
At Savannah River

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.3 x 10-5	3.3 x 10-8
MCW	1.3 x 10-6	5.3 x 10-10
MOI (New ECF)*	4.8 x 10-7	2.4 x 10-10
MOI (Barnwell Plant)	3.8 x 10-6	1.9 x 10-9
NPA	2.1 x 10-8	1.1 x 10-11

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579,541	3.6 x 10-2	1.8 x 10-5

* MOI (New ECF) applies if spent fuel facility is constructed on the Savannah River Site.
**MOI (Barnwell Plant) applies if spent fuel facility is constructed at Barnwell Nuclear Fuel Plant.

Table F.1.4.1.6-3. Summary of Exposure Calculation Results.
For Normal Operations - Dry Cell Operations
At Hanford

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.1 x 10-5	3.2 x 10-8
MCW	1.5 x 10-6	6.1 x 10-10
MOI (New ECF)*	2.4 x 10-7	1.2 x 10-10
MOI (FMEF)**	4.4 x 10-7	2.2 x 10-10
NPA	1.3 x 10-8	6.5 x 10-12

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375,800	8.0 x 10-3	4.0 x 10-6

* MOI (New ECF) applies if spent fuel facility is constructed at the 200 area on the Hanford Site.

**MOI (FMEF) applies if spent fuel facility is constructed at the Fuels and Materials Examination Facility.

Table F.1.4.1.6-4. Summary of Exposure Calculation Results.
For Normal Operations - Dry Cell Operations
At Nevada Test Site

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.5 x 10-5	1.5 x 10-8
MCW	3.7 x 10-9	1.5 x 10-12
MOI	3.4 x 10-7	1.7 x 10-10

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13,792	1.8 x 10-4	9.0 x 10-8

Table F.1.4.1.6-5. Summary of Exposure Calculation Results.
For Normal Operations - Dry Cell Operations
At Oak Ridge

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.1 x 10-4	4.4 x 10-8
MCW	1.1 x 10-7	4.6 x 10-11
MOI	8.9 x 10-5	4.5 x 10-8

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871,531	1.0 x 10-1	5.0 x 10-5

F.1.4.2 Accident Evaluation. The analysis of airborne releases from hypothetical accidents is

evaluated with RSAC-5. Unless stated otherwise, the following conditions were used when performing calculations with RSAC-5. In most cases, these conditions are taken directly as defaults from the code.

Meteorological Data

- Wind speed, direction, and Pasquill stability are taken from 50% and 95% meteorology. See Section F.1.3.5 for a discussion of meteorological conditions.
- The release is calculated as occurring at ground level (0 m).
- Mixing layer height is 400 meters (1320 feet). Airborne materials freely diffuse in the atmosphere near ground level in what is known as the mixing depth. A stable layer exists above the mixing depth which restricts vertical diffusion.
- Wet deposition is zero (no rain occurs to accelerate deposition and reduce the area affected).
- Dry deposition of the cloud is modeled. During movement of the radioactive plume, a fraction of the plume is deposited on the ground due to gravitational forces and becomes available for exposure by ground surface radiation and ingestion.
- The quantity of deposited radioactive material is proportional to the material size and speed. The following dry deposition velocities (m/s) were used:
  solids = 0.001 halogens = 0.01 noble gases = 0.0
  cesium = 0.001 ruthenium = 0.001.
- If radioactive releases occur through a stack, then additional plume dispersion can be accounted for by calculating a jet plume rise. In this analysis, jet plume rise is ignored.
- When released gases have a heat content, the plume can disperse more quickly. In this calculation, buoyant plume effects are ignored.

Inhalation Data

- Breathing rate is 3.33 x 10-4 cubic meters per second (cu m/s) for worker, MCW, and NPA; 2.66 x 10-4 cu m/s for people at site boundary and beyond.
- Particle size is 1.0 micron.
- The internal exposure period is 50 years for individual organs and tissues which have radionuclides committed.
- Exposure to the entire plume for the general public. The worker, MCW, and NPA are exposed as discussed in Section F.1.3.9.
- Inhalation exposure factors based on ICRP 30.

Ground Surface Exposure

- Exposed to contaminated soil for 1 year for the general public. See Section F.1.3.9 for additional details.
- Building shielding factor is 0.7 which exposes the individual to contaminated soil for 16 hours a day.

Ingestion Data

- Ingestion numbers will be reduced by a factor of 10 to account for only 10% of the food consumed being grown locally (such as in a person's garden).
- The following changes from RSAC-5 defaults were used:

  Annual Dietary Consumption Rates:

  177 Kg/yr Stored Vegetables (produce)
  18.3 Kg/yr Fresh Vegetables (leafy)
  94 Kg/yr Meat
  112 L/yr Milk.

F.1.4.2.1 Water Pool Storage. In the analysis of a spent fuel storage pool, a number of possible disturbances and minor accidents have been postulated. A prerequisite for a large release of radioactive material to the environment under more severe accident conditions is the damage of the cladding of a fairly large amount of stored fuel, with an accompanying release of gaseous and airborne particles of radioactive material from the fuel. Several conceivable mechanisms which might lead to this situation are the possibility that the fuel overheats so that the fuel cladding loses its integrity or there is a massive mechanical impact on the stored fuel.

The only way for the fuel to overheat would be to lose enough pool water such that cooling of the stored fuel ceases and the fuel temperature increases to fission product release temperatures due to decay heat. The pool water could be lost by leakage at a rate in excess of the makeup system capability. Unless a catastrophic event like an earthquake causes severe damage to the structure of the water pool, loss of water from the pool structure would be a slow phenomenon with only gradually increasing severity for which corrective measures can be taken in due time. Additionally, a thermal analysis was conducted to demonstrate that fuel overheating is not possible in the event of a drained water pool.

The circumstances in which an event could lead to severe mechanical loading of the fuel have been identified as:

- accidents during handling of heavy items, such as a lifting device failure
- external events (earthquake, tornado, flood, aircraft crash, etc.) which could cause structural failure.

Prevention of inadvertent, uncontrolled nuclear chain reactions is generally assured by the design of the racks for the fuel, primarily by diminishing the chances for a chain reaction by spacing the fuel element bundles far enough apart to eliminate the possibility. Special attention is given to the risk of accidental criticality which might be experienced in fuel transport and handling operations.

Uncontrolled nuclear reaction is prevented during fuel handling by applying the principle of transferring one fuel element, module, or container at a time. In addition, fuel handling rules are developed to ensure that criticality cannot occur. The double accident criterion is applied to ensure that criticality would not occur following two severe, concurrent, unrelated accidents. Thus, three fuel handling accidents are required to reach an uncontrolled nuclear chain reaction.

F.1.4.2.1.1 Drained Water Pool.

F.1.4.2.1.1.1 Description of Conditions. In this hypothetical accident scenario, a

catastrophic event, like an earthquake, causes severe damage to the structure of the water pool, resulting in a complete loss of pool water. A thermal analysis of spent fuel in a water pool was conducted to demonstrate that clad failure or fuel melting is not possible in the event of an accidentally drained water pool. Air circulation through the fuel racks and fuel units was shown to be sufficient to prevent clad failure in the unlikely event of complete loss of pool water. However, the loss of water could result in increased direct radiation and a release of corrosion products.

F.1.4.2.1.1.2 Source Term. Conditions used in developing the source term are as follows:

- 300 naval fuel units would be in the water pool.
- The thermal analysis demonstrates that no fission product release would occur during the accident.
- The amount of corrosion products on the fuel units is based on best estimate values.
- The release to the environment would occur at a constant rate over a 15-minute period.
- One percent of the original corrosion products from the fuel units might be released to the atmosphere due to thermal air currents. Additionally, 10% of the corrosion products could be released to the environment with the pool water.
- The following amounts of corrosion product nuclides might be released to the atmosphere. As noted above, the release to the water environment is 10 times these values. This listing includes nuclides that result in at least 99% of the exposure.
- No filtration by High Efficiency Particulate Air (HEPA) filters is assumed.

Nuclide	Curies
Co-60	3.6
Fe-55	6.6
Co-58	1.3
Mn-54	2.2 x 10-1
Fe-59	1.9 x 10-2

F.1.4.2.1.1.3 Results. The following table summarizes the public health risk to the general

population that might result from the hypothetical drained water pool accident at each location. The number of fatal cancers would be expected to occur over a 50-year period. "Risk" is defined as the number of fatal cancers times the probability of occurrence. The results are presented for the design basis accident with 50% and 95% meteorology. For INEL, the evaluation basis earthquake results in a 0.24 g peak ground acceleration at the ECF (Rizzo 1994). This is based on the event being initiated at the Howe earthquake epicenter and involving a surface rupture length of 34 kilometers. Using the medium response spectra, which is appropriate for a risk oriented analysis, the analyses of the structures at the INEL-ECF indicate that damage sufficient to cause the pool to drain would not occur if the pool is filled, but that, if several sections of the water pool were empty, a crack could develop in the area between the wall and floor of some of the older sections of the water pool. However, the INEL-ECF water pools are nearly always filled. Sections of the pool are only drained if maintenance work is necessary within the pools. Taking into account the probability of the initiating seismic event (1 x 10-4 per year to 4 x 10-4 per year) and the probability the earthquake will occur with a section of the pool drained, the total probability of occurrence of an event leading to draining of the pool is estimated to be in the range of 10-5 to 10-6 per year. A value of 10-5 was used to develop the risk results in the table.

A beyond design basis seismic event was also considered. For INEL, this beyond design basis earthquake is based on a scenario that results in a peak ground acceleration at the INEL-ECF of 0.40 g (Rizzo 1994). Analysis of this event has shown that some cracks could develop. The probability of this beyond design basis event is estimated to be in the range of 10-6 to 10-7 per year based on the probability of the initiating seismic event (2 x 10-5 to 6 x 10-5), and the probability of failure of the mitigative actions that would be taken to prevent the pool from draining. A value of 10-6 was selected to calculate risk for this beyond design basis event. Any cracks developed as a result of either a design basis or a beyond design basis seismic event are expected to be small and mitigative actions could be taken to stop the pool from draining. Analysis has shown that air cooling is sufficient to maintain fuel integrity if the pool was drained. No overheating of fuel would occur; hence, no fission products would be released even if the pool were completely drained. The consequences calculated stem from the release of radioactive corrosion products within the pool water and would be the same for the design basis and beyond design basis seismic events. Since the consequences are the same, the following table uses the accident probability for the design basis seismic event since that results in the larger risk.

For locations other than INEL, water pools might need to be constructed. For these locations, it was expected that the design approaches would be similar to or better than were used in the construction of the INEL-ECF. Therefore, a probability value of 10-5 per year was also used at these locations for the total probability that a design basis seismic event would lead to draining of a water pool. Consequences were based on site specific population data and meteorology.

Drained Water Pool Summary

Site	Maximally exposed off-site individual (MOI) (rem)	No. of fatal cancers if accident occurs	Risk per year
INEL	1.7 x 10-2	1.7 x 10-2	1.7 x 10-7
Savannah River	1.6 x 10-2	1.1 x 10-1	1.1 x 10-6
Hanford	6.3 x 10-3	4.7 x 10-2	4.7 x 10-7
Puget Sound	1.4	5.1 x 10-1	5.1 x 10-6
Pearl Harbor	7.9 x 10-1	1.1	1.1 x 10-5
Norfolk	3.0	6.0 x 10-1	6.0 x 10-6
Portsmouth	1.6	3.4 x 10-1	3.4 x 10-6
Kesselring	2.9 x 10-1	2.5 x 10-1	2.5 x 10-6
Nevada Test Site	3.3 x 10-2	1.9 x 10-3	1.9 x 10-8
Oak Ridge	5.2	1.8 x 10-1	1.8 x 10-6

The risk for this hypothetical accident is generally more severe at Navy shipyards than at the DOE sites. At all sites, this accident results in the highest risk of the wet storage accidents evaluated.

For the hypothetical drained water pool scenario, the radioactive plume might result in contamination of the ground to a downwind distance of 0.29 mile. This would yield a total area impacted by the accident of approximately 11 acres. The calculated downwind distance would be contained within the boundaries of all sites under evaluation with the exception of Oak Ridge and Norfolk.

Table F.1.4.2.1.1-1. Summary of Exposure Calculation Results.
For Wet Storage - Drained Water Pool
At INEL

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.5 x 10-1	3.0 x 10-4
MCW	6.9 x 10-4	2.7 x 10-7
NPA	3.9 x 10-4	2.0 x 10-7
MOI	2.8 x 10-3	1.4 x 10-6
	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 115690	6.7	3.3 x 10-3

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1	8.3 x 10-4
MCW	7.6 x 10-3	3.0 x 10-6
NPA	2.3 x 10-3	1.2 x 10-6
MOI	1.7 x 10-2	8.5 x 10-6
	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 115690	3.5 x 101	1.7 x 10-2

Table F.1.4.2.1.1-2. Summary of Exposure Calculation Results.
For Wet Storage - Drained Water Pool
At Savannah River

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.4 x 10-1	1.3 x 10-4
MCW	2.0 x 10-2	7.9 x 10-6
NPA	2.5 x 10-4	1.3 x 10-7
MOI (New ECF)	3.5 x 10-3	1.8 x 10-6
MOI (Barnwell)	1.3 x 10-2	6.3 x 10-6
	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 579541	2.4 x 101	1.2 x 10-2

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1	8.3 x 10-4
MCW	2.5 x 10-1	1.0 x 10-4
NPA	4.3 x 10-3	2.1 x 10-6
MOI (New ECF)	1.6 x 10-2	8.0 x 10-6
MOI (Barnwell)	1.4 x 10-1	7.2 x 10-5
	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 579541	2.2 x 102	1.1 x 10-1

Table F.1.4.2.1.1-3. Summary of Exposure Calculation Results.
For Wet Storage - Drained Water Pool
At Hanford

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.4 x 10-1	1.3 x 10-4
MCW	2.6 x 10-2	1.0 x 10-5
NPA	3.0 x 10-4	1.5 x 10-7

MOI (New ECF)	8.3 x 10-4	4.2 x 10-7
MOI (FMEF)	1.7 x 10-3	8.6 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375860	4.8	2.4 x 10-3

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1	8.3 x 10-4
MCW	1.6 x 10-1	6.6 x 10-5
NPA	4.8 x 10-3	2.4 x 10-6
MOI (New ECF)	6.3 x 10-3	3.2 x 10-6
MOI (FMEF)	2.2 x 10-2	1.1 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375860	9.4 x 101	4.7 x 10-2

Table F.1.4.2.1.1-4. Summary of Exposure Calculation Results.
For Wet Storage - Drained Water Pool
At Puget Sound

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.8 x 10-1	7.3 x 10-5
MCW	N/A	N/A
NPA	2.2 x 10-1	1.1 x 10-4
MOI	1.2 x 10-1	6.0 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2975810	1.7 x 102	8.2 x 10-2

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1	8.3 x 10-4
MCW	N/A	N/A
NPA	2.6	1.3 x 10-3
MOI	1.4	7.2 x 10-4
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2975810	1.0 x 103	5.1 x 10-1

Table F.1.4.2.1.1-5. Summary of Exposure Calculation Results.
For Wet Storage - Drained Water Pool
At Pearl Harbor

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.5 x 10-1	3.0 x 10-4
MCW	N/A	N/A
NPA	1.9 x 10-1	9.7 x 10-5
MOI	2.0 x 10-1	9.8 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	8.0 x 102	4.0 x 10-1

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1	8.3 x 10-4

MCW	N/A	N/A
NPA	6.3	3.1 x 10-3
MOI	7.9 x 10-1	3.9 x 10-4
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	2.2 x 103	1.1

Table F.1.4.2.1.1-6. Summary of Exposure Calculation Results.
For Wet Storage - Drained Water Pool
At Norfolk

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.8 x 10-1	7.4 x 10-5
MCW	N/A	N/A
NPA	4.6 x 10-2	2.3 x 10-5
MOI	2.8 x 10-1	1.4 x 10-4
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	1.5 x 102	7.7 x 10-2

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1	8.3 x 10-4
MCW	N/A	N/A
NPA	5.3 x 10-1	2.7 x 10-4
MOI	3.0	1.5 x 10-3
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	1.2 x 103	6.0 x 10-1

Table F.1.4.2.1.1-7. Summary of Exposure Calculation Results.
For Wet Storage - Drained Water Pool
At Portsmouth

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.8 x 10-1	7.3 x 10-5
MCW	N/A	N/A
NPA	4.4 x 10-2	2.2 x 10-5
MOI	1.3 x 10-1	6.4 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	6.5 x 101	3.2 x 10-2

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1	8.3 x 10-4
MCW	N/A	N/A
NPA	9.8 x 10-1	4.9 x 10-4
MOI	1.6	7.9 x 10-4
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	6.7 x 102	3.4 x 10-1

Table F.1.4.2.1.1-8. Summary of Exposure Calculation Results.
For Wet Storage - Drained Water Pool
At Kesselring

50% METEOROLOGY

Likelihood

Location	Total EDE (rem)	of Fatal Cancer
Worker	1.8 x 10-1	7.4 x 10-5
MCW	N/A	N/A
NPA	N/A	N/A
MOI	2.0 x 10-2	1.0 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	7.1 x 101	3.6 x 10-2

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1	8.3 x 10-4
MCW	N/A	N/A
NPA	N/A	N/A
MOI	2.9 x 10-1	1.5 x 10-4
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	5.0 x 102	2.5 x 10-1

Table F.1.4.2.1.1-9. Summary of Exposure Calculation Results.
For Wet Storage - Drained Water Pool
At Nevada Test Site

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.2 x 10-1	4.8 x 10-5
MCW	9.3 x 10-5	3.7 x 10-8
NPA	N/A	N/A
MOI	1.5 x 10-3	7.5 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	3.2 x 10-1	1.6 x 10-4

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1	8.3 x 10-4
MCW	5.4 x 10-3	2.2 x 10-6
NPA	N/A	N/A
MOI	3.3 x 10-2	1.7 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	3.7	1.9 x 10-3

Table F.1.4.2.1.1-10. Summary of Exposure Calculation Results.
For Wet Storage - Drained Water Pool
At Oak Ridge

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.5 x 10-1	3.0 x 10-4
MCW	2.0 x 10-2	7.9 x 10-6
NPA	2.6 x 10-1	1.3 x 10-4
MOI	8.2 x 10-1	4.1 x 10-4
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	7.1 x 101	3.6 x 10-2

95% METEOROLOGY

Likelihood

Location	Total EDE (rem)	of Fatal Cancer
Worker	2.1	8.3 x 10-4
MCW	1.2 x 10-1	4.8 x 10-5
NPA	1.6	8.2 x 10-4
MOI	5.2	2.6 x 10-3

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 871531	3.5 x 102	1.8 x 10-1

F.1.4.2.1.2 Accidental Criticality.

F.1.4.2.1.2.1 Description of Conditions.

In this hypothetical accident scenario, an accidental uncontrolled chain reaction producing 1 x 1019 fissions is postulated. The criticality occurs in the water pool which is not emptied by the event and does not subsequently empty. Release of fission products includes those specified in Regulatory Guide 3.34 (NUREG 1979b) from the criticality, plus fission products remaining in the fuel as a result of the original use. Removal of fission products by the pool water is included.

F.1.4.2.1.2.2 Source Term.

Conditions used in developing the source term are as follows:

- The fraction of the fission products released to the building is 100% of the noble gases, 25% of the halogens, 0.1% of the ruthenium (Elder et al. 1986), and 0.05% of the cesium and remaining solids.
- The original inventory of fission products from two naval fuel units are available for release in addition to those created by the criticality event.
- A High Efficiency Particulate Air (HEPA) filter removes 99.9% of the solid fission products from the plume.
- The release to the environment occurs at a constant rate over a 15-minute period. This is conservative as compared to the 8-hour release allowed in Regulatory Guide 3.34.
- The following amounts of radionuclides are released to the environment. This listing includes nuclides that result in at least 99% of the possible exposure.

Nuclide	Curies	Nuclide	Curies
Te-133	3.4 x 103	I-132	1.7 x 100
I-134	3.5 x 102	Sr-90	1.94 x 10-2
I-135	1.2 x 102	Y-91m	4.3 x 10-8
Cs-138	1.6 x 10-4	Rb-88	1.7 x 10-5
Rb-89	6.05 x 10-4	Y-91	1.1 x 10-2
Pu-238	3.7 x 10-4	Cs-139	7.3 x 10-3
Br-84	2.3 x 102	Ba-142	4.8 x 10-3
I-133	2.4 x 100	Y-93	1.3 x 10-6
Sr-91	5.4 x 10-6	Ba-137m	1.9 x 10-2
Sr-92	2.4 x 10-4	Ru-106	7.6 x 10-3
Ba-139	6.9 x 10-6	Zr-95	1.4 x 10-2
Ba-141	8.8 x 10-4	Sr-89	7.01 x 10-3
I-129	5.1 x 10-3	Eu-154	1.3 x 10-3
I-131	3.2 x 10-1		
H-3	1.42 x 102		
Cs-134	1.5 x 10-2		
Ba-140	2.5 x 10-5		
I-136	1.1 x 104		
Cs-137	2.0 x 10-2		
Ce-144	4.5 x 10-2		
Nb-95	2.7 x 10-2		
Rb-90	2.2 x 10-2		

F.1.4.2.1.2.3 Results. The following table summarizes the public health risk to the general population that would result from the hypothetical criticality accident at each location. The number of fatal cancers would be expected to occur over a 50-year period. "Risk" is defined as the number of fatal cancers times the probability of occurrence. An accidental criticality during spent nuclear fuel handling operations is extremely unlikely. There are no known events of this type which have occurred during handling of fuel modules either in or out of water. Due to the need for a neutron moderator, extremely large quantities of naval fuels would be required to achieve criticality in a dry state. Fuel handling procedures in water in conjunction with required physical barriers ensure that a double accident criterion is met. This criterion specifies that the fuel will not attain a critical condition even if any two unlikely and unrelated accidents occur at the same time. The DOE criticality control requirement is a double contingency criterion which specifies that a second unlikely and unrelated accident would be required for a critical condition to result. To satisfy the NNPP double accident criterion, naval fuel handling operations are conducted in the following manner:

- No more than one module is to be handled in one area at a time.
- If two modules are capable of achieving a critical condition, separation must be maintained by a positive barrier between them which is locked in place.
- If three modules are required to achieve criticality, a physical barrier which does not need to be locked is required to be placed between them.
- If four or more modules are needed to achieve criticality, no barriers are required, but modules are to remain separated.

Based on the above requirements, at least three distinct errors are needed to achieve accidental criticality. For example, bringing two or more modules in close proximity is always prohibited. Failure to maintain separation constitutes an error. Secondly, failure to recognize and use physical barriers when required also constitutes an error. A human error rate of 10-3 per operation (Swain and Guttman 1983) is taken as the probability of error for trained personnel. Further, because all fuel handling operations must be checked by an independent verifier, an additional factor of 10-1 may be taken for a probability of 10-4 for each independent error. For naval fuel handling, an error in which two modules are brought together is a violation of a fundamental requirement. Compliance with this requirement alone ensures that a subcritical state is maintained. Therefore, the bringing of two or more modules together error is considered separate and independent of all other errors. Because a second error must occur to cause accidental criticality, an additional reduction in the probability is warranted. For example, failure to recognize the need to install a barrier when required is such an error. Because this mistake is independent of the first error and has been checked, a second value of 10-4 is appropriate for a total value of 10-8 per year. This probability is taken as the likelihood of a criticality for movement of a single module. Based on an estimated 1,000 fuel handling operations a year, a value of 10-5 per year has been used in the risk assessment of accidental criticality.

Accidental Criticality Summary

Site	Maximally exposed off-site individual (MOI) (rem)	No. of fatal cancer if accident occurs	Risk per year
INEL	9.2 x 10-3	6.4 x 10-3	6.4 x 10-8
Savannah River	9.4 x 10-3	4.5 x 10-2	4.5 x 10-7
Hanford	2.8 x 10-3	1.6 x 10-2	1.6 x 10-7
Puget Sound	1.3	2.8 x 10-1	2.8 x 10-6
Pearl Harbor	6.7 x 10-1	6.0 x 10-1	6.0 x 10-6
Norfolk	2.7	3.5 x 10-1	3.5 x 10-6

Portsmouth	1.4	1.5 x 10-1	1.5 x 10-6
Kesselring	2.3 x 10-1	1.1 x 10-1	1.1 x 10-6
Nevada Test Site	2.0 x 10-2	7.0 x 10-4	7.0 x 10-9
Oak Ridge	4.7	8.8 x 10-2	8.8 x 10-7

The risk for this hypothetical accident is more severe at Navy shipyards than at the DOE sites. At all sites, this accident results in the second highest risk of the wet storage accidents evaluated.

For the hypothetical criticality accident scenario, the radioactive plume might cause contamination of the ground to a downwind distance of 0.25 mile. This would yield a total area impacted by the accident of approximately 8 acres. The calculated downwind distance would be contained within the boundaries of all sites under evaluation with the exception of Oak Ridge and Norfolk.

Table F.1.4.2.1.2-1. Summary of Exposure Calculation Results.
For Wet Storage - Accidental Criticality
At INEL

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.0	1.2 x 10-3
MCW	1.3 x 10-3	5.1 x 10-7
NPA	5.9 x 10-4	2.9 x 10-7
MOI	2.0 x 10-3	1.0 x 10-6
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	5.5	2.8 x 10-3

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2 x 10-3
MCW	1.3 x 10-2	5.0 x 10-6
NPA	2.8 x 10-3	1.4 x 10-6
MOI	9.2 x 10-3	4.6 x 10-6
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	1.3 x 101	6.4 x 10-3

Table F.1.4.2.1.2-2. Summary of Exposure Calculation Results.
For Wet Storage - Accidental Criticality
At Savannah River

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.3	5.3 x 10-4
MCW	6.8 x 10-2	2.7 x 10-5
NPA	7.4 x 10-4	3.7 x 10-7
MOI (New (ECF)	3.3 x 10-3	1.6 x 10-6
MOI (Barnwell)	1.2 x 10-2	5.9 x 10-6
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	2.2 x 101	1.1 x 10-2

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2 x 10-3
MCW	7.9 x 10-1	3.1 x 10-4
NPA	6.4 x 10-3	3.2 x 10-6
MOI (New ECF)	9.4 x 10-3	4.7 x 10-6
MOI (Barnwell)	1.1 x 10-1	5.3 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers

Population of 579541	8.9 x 101	4.5 x 10-2

Table F.1.4.2.1.2-3. Summary of Exposure Calculation Results.
For Wet Storage - Accidental Criticality
At Hanford

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.3	5.3 x 10-4
MCW	8.9 x 10-2	3.5 x 10-5
NPA	6.6 x 10-4	3.3 x 10-7
MOI (New (ECF)	4.7 x 10-4	2.4 x 10-7
MOI (FMEF)	1.3 x 10-3	6.7 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375860	2.2	1.1 x 10-3

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2 x 10-3
MCW	4.9 x 10-1	2.0 x 10-4
NPA	6.9 x 10-3	3.5 x 10-6
MOI (New ECF)	2.8 x 10-3	1.4 x 10-6
MOI (FMEF)	1.2 x 10-2	6.1 x 10-6
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375860	3.1 x 101	1.6 x 10-2

Table F.1.4.2.1.2-4. Summary of Exposure Calculation Results.
For Wet Storage - Accidental Criticality
At Puget Sound

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.2 x 10-1	2.9 x 10-4
MCW	N/A	N/A
NPA	7.7 x 10-1	3.8 x 10-4
MOI	1.1 x 10-1	5.6 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2975810	2.3 x 102	1.1 x 10-1

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2 x 10-3
MCW	N/A	N/A
NPA	8.8	4.4 x 10-3
MOI	1.3	6.3 x 10-4
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2975810	5.6 x 102	2.8 x 10-1

Table F.1.4.2.1.2-5. Summary of Exposure Calculation Results.
For Wet Storage - Accidental Criticality
At Pearl Harbor

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.0	1.2 x 10-3
MCW	N/A	N/A

NPA	7.0 x 10-1	3.5 x 10-4
MOI	1.8 x 10-1	8.9 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	5.6 x 102	2.8 x 10-1

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2 x 10-3
MCW	N/A	N/A
NPA	2.2 x 101	2.2 x 10-2
MOI	6.7 x 10-1	3.4 x 10-4
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	1.2 x 103	6.0 x 10-1

Table F.1.4.2.1.2-6. Summary of Exposure Calculation Results.
For Wet Storage - Accidental Criticality
At Norfolk

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.4 x 10-1	2.9 x 10-4
MCW	N/A	N/A
NPA	1.6 x 10-1	8.2 x 10-5
MOI	2.7 x 10-1	1.3 x 10-4
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	1.6 x 102	8.1 x 10-2

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2 x 10-3
MCW	N/A	N/A
NPA	1.8	8.8 x 10-4
MOI	2.7	1.4 x 10-3
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	7.0 x 102	3.5 x 10-1

Table F.1.4.2.1.2-7. Summary of Exposure Calculation Results.
For Wet Storage - Accidental Criticality
At Portsmouth

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.2 x 10-1	2.9 x 10-4
MCW	N/A	N/A
NPA	1.5 x 10-1	7.7 x 10-5
MOI	1.2 x 10-1	5.9 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	7.9 x 101	4.0 x 10-2

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2 x 10-3
MCW	N/A	N/A

NPA	3.3	1.6 x 10-3
MOI	1.4	7.0 x 10-4
	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 2432627	2.9 x 102	1.5 x 10-1

Table F.1.4.2.1.2-8. Summary of Exposure Calculation Results. For Wet Storage - Accidental Criticality At Kesselring

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.4 x 10-1	2.9 x 10-4
MCW	N/A	N/A
NPA	N/A	N/A
MOI	1.9 x 10-2	9.7 x 10-6
	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 1148587	5.6 x 101	2.8 x 10-2

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2 x 10-3
MCW	N/A	N/A
NPA	N/A	N/A
MOI	2.3 x 10-1	1.2 x 10-4
	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 1148587	2.2 x 102	1.1 x 10-1

Table F.1.4.2.1.2-9. Summary of Exposure Calculation Results. For Wet Storage - Accidental Criticality At Nevada Test Site

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	4.8 x 10-1	1.9 x 10-4
MCW	2.1 x 10-4	8.0 x 10-8
NPA	N/A	N/A
MOI	1.5 x 10-3	7.3 x 10-7
	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 13792	4.3 x 10-1	2.2 x 10-4

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2 x 10-3
MCW	8.1 x 10-3	3.3 x 10-6
NPA	N/A	N/A
MOI	2.0 x 10-2	9.9 x 10-6
	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 13792	1.4	7.0 x 10-4

Table F.1.4.2.1.2-10. Summary of Exposure Calculation Results. For Wet Storage - Accidental Criticality At Oak Ridge

50% METEOROLOGY

	Total EDE	Likelihood of Fatal

Location	(rem)	Cancer
Worker	3.0	1.2 x 10-3
MCW	6.6 x 10-2	2.6 x 10-5
NPA	9.1 x 10-1	4.6 x 10-4
MOI	7.6 x 10-1	3.8 x 10-4
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	7.4 x 101	3.7 x 10-2

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2 x 10-3
MCW	3.6 x 10-1	1.4 x 10-4
NPA	5.6	2.8 x 10-3
MOI	4.7	2.4 x 10-3
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	1.8 x 102	8.8 x 10-2

F.1.4.2.1.3 Mechanical Damage from Operator Error, Crane Failure, or Similar Accidents

F.1.4.2.1.3.1 Description of Conditions. Accidental mechanical damage to spent fuel was evaluated. The hypothetical accident included damage to one fuel unit, allowing fission products within the elements to escape through the clad failures. All gas and some volatile and solid nuclides were calculated to be released to the pool. The release fractions are consistent with severe accident analyses and Regulatory Guide 1.4. Due to the presence of pool water, no solids would be released into the air inside the facility.

F.1.4.2.1.3.2 Source Term. Conditions used in developing the source term are as follows:

- One fuel unit is damaged because only one fuel unit would be handled at a time and the storage facility design prevents damage to stored units from such events.
- One percent of the fuel is damaged and those fission products are available for release.
- All (100%) of the noble gases are released to the environment.
- Approximately 25% of the halogens are released to the pool and 90% of these fission products are absorbed in the water as they rise through the pool water. Therefore, 2.5% of the halogens are released to the air inside the facility.
- Due to the gaseous nature of the released fission products, installed HEPA filters would not remove them once they are released to the air in the building.
- The release to the environment occurs at a constant rate over a 15-minute period.
- There is no particulate fission product release to the atmosphere due to the presence of pool water.
- The following amounts of radionuclides could be released to the environment. This listing includes nuclides that result in at least 99% of the possible exposure.

Nuclides	Curies

H-3	1.42
I-129	2.52 x 10-6
I-131	5.37 x 10-5

F.1.4.2.1.3.3 Results. The following table summarizes the public health risk to the general population that would result from the hypothetical mechanical damage accident at each location. The number of fatal cancers would be expected to occur over a 50-year period. "Risk" is defined as the number of fatal cancers times the probability of occurrence. The probability of the occurrence of fuel damage is small based on the conservative fuel handling rules. At the INEL-ECF, it is recognized that the drop of a heavy container into a storage rack could crush the rack and the stored fuel and so heavy casks are never moved over the storage rack area. The heavy containers are brought only into an empty receiving area to discharge a single fuel unit. The spent fuel is removed from the receiving area before the next fuel unit is brought into the receiving area. Therefore, two errors must occur before damaged fuel is possible. The first is that fuel is improperly left in the discharge station while the heavy cask is moved over the discharge station. The second is that the cask must accidentally fall from the overhead crane or the crane must fail. The probability of failure associated with crane failure has been taken as 10-2 per year. Further, the crane failure must also occur in the right location and the drop must be high enough that sufficient energy is available to damage both the discharge station structurals and the fuel inside. An additional factor of 10-2 has been taken for this event, giving the total probability of 10-4 for the drop of the cask in the right location. Allowing a fuel unit to remain in the stand requires an operator error because fuel handling procedures call for the fuel unit to be removed from the stand and taken to an underwater storage location away from the receiving area. In addition, because independent overchecking is required for all fuel movement, an error by a verifier is also required. Therefore, based on operator error rates (Swain and Guttman 1983), the likelihood of this error is taken as 10-4 per year. Hence, the combined probability of cask drop on a fuel unit is taken as 10-8 per year per fuel movement. Then, taking an estimated rate of 1,000 fuel movements per year, the overall probability is taken as 10-5 events per year.

Wet Storage Mechanical Damage Summary

Site	Maximally exposed off-site individual (MOI) (rem)	No. of fatal cance if accident occurs	Risk per year
INEL	2.6 x 10-6	5.3 x 10-6	5.3 x 10-11
Savannah River	2.2 x 10-6	2.0 x 10-5	2.0 x 10-10
Hanford	9.8 x 10-7	8.6 x 10-6	8.6 x 10-11
Puget Sound	1.7 x 10-4	7.2 x 10-5	7.2 x 10-10
Pearl Harbor	9.3 x 10-5	1.5 x 10-4	1.5 x 10-9
Norfolk	3.5 x 10-4	8.0 x 10-5	8.0 x 10-10
Portsmouth	1.9 x 10-4	5.6 x 10-5	5.6 x 10-10
Kesselring	3.6 x 10-5	6.0 x 10-5	6.0 x 10-10
Nevada Test Site	4.6 x 10-6	5.6 x 10-7	5.6 x 10-12
Oak Ridge	5.9 x 10-4	3.4 x 10-5	3.4 x 10-10

The risk for this hypothetical accident is generally more severe at Navy shipyards than at the DOE sites. At all sites, this accident results in the lowest or next to the lowest risk of the wet storage accidents evaluated.

For the hypothetical wet storage mechanical damage accident scenario, the radioactive plume might cause contamination of the ground to a downwind distance of less than 0.06 mile. This would yield a total area impacted by the accident of less than 0.5 acre. The calculated downwind distance would be contained within the boundaries of all sites under evaluation.

Table F.1.4.2.1.3-1. Summary of Exposure Calculation Results.
For Wet Storage - Mechanical Damage
At INEL

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.9 x 10-4	7.6 x 10-8
MCW	2.5 x 10-7	9.6 x 10-11
NPA	1.5 x 10-7	7.4 x 10-11
MOI	5.7 x 10-7	2.9 x 10-10
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	5.0 x 10-3	2.5 x 10-6

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.2 x 10-4	2.1 x 10-7
MCW	2.4 x 10-6	9.6 x 10-10
NPA	8.3 x 10-7	4.2 x 10-10
MOI	2.6 x 10-6	1.3 x 10-9
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	1.1 x 10-2	5.3 x 10-6

Table F.1.4.2.1.3-2. Summary of Exposure Calculation Results.
For Wet Storage - Mechanical Damage
At Savannah River

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.4 x 10-5	3.4 x 10-8
MCW	5.2 x 10-6	2.1 x 10-9
NPA	9.1 x 10-8	4.5 x 10-11
MOI (New ECF)	3.9 x 10-7	1.9 x 10-10
MOI (Barnwell)	1.5 x 10-6	7.4 x 10-10
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	7.1 x 10-3	3.5 x 10-6

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.2 x 10-4	2.1 x 10-7
MCW	6.7 x 10-5	2.6 x 10-8
NPA	1.4 x 10-6	7.2 x 10-10
MOI (New ECF)	2.2 x 10-6	1.1 x 10-9
MOI (Barnwell)	1.8 x 10-5	9.0 x 10-9
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	4.1 x 10-2	2.0 x 10-5

Table F.1.4.2.1.3-3. Summary of Exposure Calculation Results.
For Wet Storage - Mechanical Damage
At Hanford

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.4 x 10-5	3.4 x 10-8
MCW	7.1 x 10-6	2.9 x 10-9
NPA	1.0 x 10-7	5.1 x 10-11
MOI (New (ECF)	1.3 x 10-7	6.5 x 10-11

MOI (FMEF)	2.4 x 10-7	1.2 x 10-10

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 375860	9.4 x 10-4	4.7 x 10-7

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.2 x 10-4	2.1 x 10-7
MCW	4.4 x 10-5	1.8 x 10-8
NPA	1.6 x 10-6	7.9 x 10-10
MOI (New ECF)	9.8 x 10-7	4.9 x 10-10
MOI (FMEF)	3.1 x 10-6	1.5 x 10-9

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 375860	1.7 x 10-2	8.6 x 10-6

Table F.1.4.2.1.3-4. Summary of Exposure Calculation Results.
For Wet Storage - Mechanical Damage
At Puget Sound

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	4.6 x 10-5	1.8 x 10-8
MCW	N/A	N/A
NPA	5.5 x 10-5	2.7 x 10-8
MOI	1.3 x 10-5	6.7 x 10-9

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 2975810	6.0 x 10-3	3.0 x 10-6

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.2 x 10-4	2.1 x 10-7
MCW	N/A	N/A
NPA	6.5 x 10-4	3.2 x 10-7
MOI	1.7 x 10-4	8.4 x 10-8

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 2975810	1.5 x 10-1	7.2 x 10-5

Table F.1.4.2.1.3-5. Summary of Exposure Calculation Results.
For Wet Storage - Mechanical Damage
At Pearl Harbor

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.9 x 10-4	7.6 x 10-8
MCW	N/A	N/A
NPA	4.9 x 10-5	2.4 x 10-8
MOI	2.3 x 10-5	1.2 x 10-8

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 817385	1.1 x 10-1	5.6 x 10-5

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.2 x 10-4	2.1 x 10-7
MCW	N/A	N/A

NPA	1.6 x 10-3	7.9 x 10-7
MOI	9.3 x 10-5	4.6 x 10-8

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	3.1 x 10-1	1.5 x 10-4

Table F.1.4.2.1.3-6. Summary of Exposure Calculation Results.
For Wet Storage - Mechanical Damage
At Norfolk

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	4.6 x 10-5	1.9 x 10-8
MCW	N/A	N/A
NPA	1.2 x 10-5	6.0 x 10-9
MOI	3.2 x 10-5	1.6 x 10-8

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	1.4 x 10-2	7.0 x 10-6

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.2 x 10-4	2.1 x 10-7
MCW	N/A	N/A
NPA	1.4 x 10-4	7.0 x 10-8
MOI	3.5 x 10-4	1.7 x 10-7

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	1.6 x 10-1	8.0 x 10-5

Table F.1.4.2.1.3-7. Summary of Exposure Calculation Results.
For Wet Storage - Mechanical Damage
At Portsmouth

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	4.6 x 10-5	1.8 x 10-8
MCW	N/A	N/A
NPA	1.1 x 10-5	5.6 x 10-9
MOI	1.5 x 10-5	7.4 x 10-9

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	3.8 x 10-3	1.9 x 10-6

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.2 x 10-4	2.1 x 10-7
MCW	N/A	N/A
NPA	2.5 x 10-4	1.3 x 10-7
MOI	1.9 x 10-4	9.3 x 10-8

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	1.1 x 10-1	5.6 x 10-5

Table F.1.4.2.1.3-8. Summary of Exposure Calculation Results.
For Wet Storage - Mechanical Damage
At Kesselring

50% METEOROLOGY

	Total EDE	Likelihood of Fatal

Location	(rem)	Cancer
Worker	4.6 x 10-5	1.9 x 10-8
MCW	N/A	N/A
NPA	N/A	N/A
MOI	3.2 x 10-6	1.6 x 10-9
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	4.7 x 10-2	2.3 x 10-5

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.2 x 10-4	2.1 x 10-7
MCW	N/A	N/A
NPA	N/A	N/A
MOI	3.6 x 10-5	1.8 x 10-8
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	1.2 x 10-1	6.0 x 10-5

Table F.1.4.2.1.3-9. Summary of Exposure Calculation Results.
For Wet Storage - Mechanical Damage
At Nevada Test Site

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.0 x 10-5	1.2 x 10-8
MCW	3.0 x 10-8	1.5 x 10-11
NPA	N/A	N/A
MOI	3.8 x 10-7	1.9 x 10-10
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	4.5 x 10-4	2.3 x 10-7

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.2 x 10-4	2.1 x 10-7
MCW	1.8 x 10-6	7.1 x 10-10
NPA	N/A	N/A
MOI	4.6 x 10-6	2.3 x 10-9
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	1.1 x 10-3	5.6 x 10-7

Table F.1.4.2.1.3-10. Summary of Exposure Calculation Results.
For Wet Storage - Mechanical Damage
At Oak Ridge

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.9 x 10-4	7.6 x 10-8
MCW	5.4 x 10-6	2.2 x 10-9
NPA	6.6 x 10-5	3.3 x 10-8
MOI	9.3 x 10-5	4.7 x 10-8
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	2.0 x 10-2	1.0 x 10-5

95% METEOROLOGY

	Total EDE	Likelihood of Fatal

Location	(rem)	Cancer
Worker	5.2 x 10-4	2.1 x 10-7
MCW	3.3 x 10-5	1.3 x 10-8
NPA	4.2 x 10-4	2.1 x 10-7
MOI	5.9 x 10-4	3.0 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	6.7 x 10-2	3.4 x 10-5

F.1.4.2.1.4 Airplane Crash.

F.1.4.2.1.4.1 Description of Conditions. Impact into water pools by aircraft with resulting

damage to the naval fuel units stored inside the pool was evaluated. Based on the probability of occurrence, as discussed in Section F.3, specific analyses were only performed for Savannah River, the Nevada Test Site, Oak Ridge, Pearl Harbor, Norfolk, and Kesselring locations. At other locations, the likelihood of occurrence is less than 10-7 per year. The hypothetical accident included damage to all fuel units stored at the water pool. Fission products and corrosion products are released from the fuel units into the water pool; however, the pool water is not released to the environment. An airplane crash into a water pool would not produce enough force to cause the pool to leak because the walls of the water pool are constructed of thick, reinforced concrete with earth surrounding them, making them very strong. In addition, it was judged unlikely that an airplane would impact the water pool at an angle steep enough to expose the floor of the pool or the walls of the pool below the water level to the direct impact. The presence of pool water results in only a release of gaseous fission products to the atmosphere.

F.1.4.2.1.4.2 Source Term. Conditions used in developing the source term are as follows:

- One percent of the fission products from each of the fuel units stored inside the pool is available for release.
- Of the available fission products, 100% of the noble gases and 25% of the halogens are released to the pool water. Due to the presence of pool water, a reduction of the halogen release by a factor of 10 prior to release to the atmosphere occurs.
- No solid fission products or corrosion products are released to the environment due to the continued presence of pool water.
- The release to the environment occurs at a constant rate over a 15-minute period.
- 300 naval fuel units would be in the water pool.
- No filtration by HEPA filters is assumed.
- The following amounts of radionuclides could be released to the environment. This listing includes nuclides that result in at least 99% of the possible exposure.

Nuclide	Curies
I-129	7.59 x 10-4
I-131	1.61 x 10-2
H-3	4.28 x 102

F.1.4.2.1.4.3 Results. The following table summarizes the public health risk to the general

population that would result from the hypothetical airplane crash accident at each location. The number of fatal cancers would be expected to occur over a 50-year period. "Risk" is defined as the number of fatal cancers times the probability of occurrence.

Water Pool Airplane Crash Summary

Site	Probability of accident per year	Maximally exposed off-site individual (MOI) (rem)	No. of fatal cancers if accident occurs	Risk per year
Savannah River	2 x 10-6	6.4 x 10-4	6.1 x 10-3	1.2 x 10-8
Pearl Harbor	2 x 10-5	2.8 x 10-2	4.6 x 10-2	9.2 x 10-7
Norfolk	4 x 10-7	1.1 x 10-1	2.4 x 10-2	9.6 x 10-9
Kesselring	2 x 10-7	1.1 x 10-2	1.8 x 10-2	3.6 x 10-9
Nevada Test Site	4 x 10-7	1.3 x 10-3	1.7 x 10-4	6.8 x 10-11
Oak Ridge	1 x 10-6	1.8 x 10-1	1.0 x 10-2	1.0 x 10-8

The risk for this hypothetical accident is most severe at Pearl Harbor. For the sites with crash probabilities less than 10-7 per year, consequences were not calculated since it is expected that they would not substantially contribute to the risk.

For the hypothetical airplane crash into a wet storage facility accident scenario, the radioactive plume might result in contamination of the ground to a downwind distance of less than 0.06 mile. This would yield a total area impacted by the accident of less than 0.5 acre. The calculated downwind distance would be contained within the boundaries of all sites that are at risk for this accident.

Table F.1.4.2.1.4-1. Summary of Exposure Calculation Results.
For Wet Storage - Airplane Crash
At Savannah River

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.5 x 10-2	1.0 x 10-5
MCW	1.6 x 10-3	6.3 x 10-7
NPA	2.8 x 10-5	1.4 x 10-8
MOI	1.1 x 10-4	5.5 x 10-8

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	2.2	1.1 x 10-3

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.6 x 10-1	6.3 x 10-5
MCW	2.0 x 10-2	8.0 x 10-6
NPA	4.3 x 10-4	2.2 x 10-7
MOI	6.4 x 10-4	3.2 x 10-7

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	1.2 x 101	6.1 x 10-3

Table F.1.4.2.1.4-2. Summary of Exposure Calculation Results.
For Wet Storage - Airplane Crash
At Pearl Harbor

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.7 x 10-2	2.3 x 10-5
MCW	N/A	N/A
NPA	1.5 x 10-2	7.3 x 10-6
MOI	6.9 x 10-3	3.5 x 10-6

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Can-

		cers
Population of 817385	3.3 x 101	1.7 x 10-2

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.6 x 10-1	6.3 x 10-5
MCW	N/A	N/A
NPA	4.7 x 10-1	2.4 x 10-4
MOI	2.8 x 10-2	1.4 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	9.2 x 101	4.6 x 10-2

Table F.1.4.2.1.4-3. Summary of Exposure Calculation Results.
For Wet Storage - Airplane Crash
At Norfolk

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.4 x 10-2	5.6 x 10-6
MCW	N/A	N/A
NPA	3.6 x 10-3	1.8 x 10-6
MOI	9.6 x 10-3	4.8 x 10-6
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	4.2	2.1 x 10-3

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.6 x 10-1	6.3 x 10-5
MCW	N/A	N/A
NPA	4.2 x 10-2	2.1 x 10-5
MOI	1.1 x 10-1	5.3 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	4.8 x 101	2.4 x 10-2

Table F.1.4.2.1.4-4. Summary of Exposure Calculation Results.
For Wet Storage - Airplane Crash
At Kesselring

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.4 x 10-2	5.6 x 10-6
MCW	N/A	N/A
NPA	N/A	N/A
MOI	9.5 x 10-4	4.8 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	1.4 x 101	7.1 x 10-3

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.6 x 10-1	6.3 x 10-5
MCW	N/A	N/A
NPA	N/A	N/A
MOI	1.1 x 10-2	5.4 x 10-6
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Can-

		cers
Population of 1148587	3.6 x 101	1.8 x 10-2

Table F.1.4.2.1.4-5. Summary of Exposure Calculation Results.
For Wet Storage - Airplane Crash
At Nevada Test Site

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	9.0 x 10-3	3.6 x 10-6
MCW	9.1 x 10-6	3.7 x 10-9
NPA	N/A	N/A
MOI	5.5 x 10-5	2.8 x 10-8
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	1.3 x 10-1	6.5 x 10-5

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.6 x 10-1	6.4 x 10-5
MCW	5.3 x 10-4	2.2 x 10-7
NPA	N/A	N/A
MOI	1.3 x 10-3	6.5 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	3.3 x 10-1	1.7 x 10-4

Table F.1.4.2.1.4-6. Summary of Exposure Calculation Results.
For Wet Storage - Airplane Crash
At Oak Ridge

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.7 x 10-2	2.3 x 10-5
MCW	1.6 x 10-3	6.5 x 10-7
NPA	2.0 x 10-2	9.9 x 10-6
MOI	2.8 x 10-2	1.4 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	6.0	3.0 x 10-3

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.6 x 10-1	6.3 x 10-5
MCW	9.9 x 10-3	3.9 x 10-6
NPA	1.3 x 10-1	6.3 x 10-5
MOI	1.8 x 10-1	8.9 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	2.0 x 101	1.0 x 10-2

F.1.4.2.1.5 HEPA Filter Fire.

F.1.4.2.1.5.1 Description of Conditions. In this hypothetical accident scenario, a fire in the

ECF High Efficiency Particulate Air (HEPA) filter banks is postulated. This accident could be initiated by the ignition of a flammable mixture released upstream of the system or by an external, unrelated fire that spreads to this system. Although the risks associated with this accident are relatively minor, it was analyzed to bound the higher probability, lower consequence type accident category. The airborne release fractions associated with this accident were conservatively chosen so that a HEPA filter failure by crushing or impact was also bounded.

F.1.4.2.1.5.2 Source Term. Conditions used in developing the source term are as follows:

- The original inventory of fission products in the filters is based on the total estimated unabated ECF releases over a 5-year period.
- One percent of the radionuclide inventory present on the filters becomes airborne during the fire. Release fractions for HEPA filters are small because the filters are constructed of material containing glass fibers which would melt during a fire and trap particles in the medium. Measurements from experiments show that one one-hundredth of 1% of the material in HEPA filters could be released during a fire, but 1% has been used in these analyses to allow for uncertainties in the final results of an individual fire.
- The release to the environment occurs at a constant rate over a 15-minute period.
- There is no increase in direct radiation due to this accident.
- The following amounts of radionuclides could be released to the environment. This listing includes nuclides that result in at least 99% of the possible exposure.
- No filtration by HEPA filters is assumed.

Nuclide	Curies	Nuclide	Curies
Cs-137	1.46 x 10-3	Co-60	2.09 x 10-3
Cs-134	2.04 x 10-4	Sr-90	8.90 x 10-4
Ba-137M	6.26 x 10-6	Y-90	8.90 x 10-4
Fe-55	2.32 x 10-3	Eu-154	9.80 x 10-5
Ni-63	2.98 x 10-3		

F.1.4.2.1.5.3 Results. The following table summarizes the public health risk to the general

population that would result from the hypothetical HEPA filter fire accident at each location. The number of fatal cancers would be expected to occur over a 50-year period. "Risk" is defined as the number of fatal cancers times the probability of occurrence. The probability of a fire in a HEPA filter is estimated based on the probability of other fires spreading to the HEPA filter system. As discussed in section F.2.4.2, a probability of 5 x 10-3 is assigned to chemical fires. The probability of HEPA fires is considered less than a chemical fire since chemicals would not be stored in the immediate vicinity of the HEPA filter system. Additionally, HEPA filters are not inherently volatile or explosive. It is estimated that the probability for an existing chemical fire to spread to the HEPA filters is less than 0.1. This results in a probability of less than 5 x 10-4 for a HEPA filter fire. A value of 5 x 10-4 was used to develop the risk results in the table.

HEPA Filter Fire Summary

Site	Maximally exposed off-site individual (MOI)	No. of fatal cancer if accident occurs	Risk per year

	(rem)		
INEL	2.5 x 10-5	5.3 x 10-5	2.7 x 10-8
Savannah River	2.1 x 10-5	1.3 x 10-4	6.5 x 10-8
Hanford	7.0 x 10-6	5.3 x 10-5	2.7 x 10-8
Puget Sound	1.6 x 10-3	6.4 x 10-4	3.2 x 10-7
Pearl Harbor	8.7 x 10-4	1.2 x 10-3	6.0 x 10-7
Norfolk	3.3 x 10-3	6.9 x 10-4	3.5 x 10-7
Portsmouth	1.7 x 10-3	3.9 x 10-4	2.0 x 10-7
Kesselring	3.5 x 10-4	3.3 x 10-4	1.7 x 10-7
Nevada Test Site	4.3 x 10-5	5.7 x 10-6	2.9 x 10-9
Oak Ridge	5.7 x 10-3	2.2 x 10-4	1.1 x 10-7

The risk for this hypothetical accident is generally more severe at the Navy shipyards than at the DOE sites.

For the hypothetical HEPA filter fire accident scenario, the radioactive plume might cause contamination of the ground to a downwind distance of less than 0.06 mile. This would yield a total area impacted by the accident of less than 0.5 acre. The calculated downwind distance would be contained within the boundaries of all sites under evaluation.

Table F.1.4.2.1.5-1. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At INEL

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.7 x 10-4	3.5 x 10-7
MCW	7.9 x 10-7	3.2 x 10-10
NPA	4.5 x 10-7	2.2 x 10-10
MOI	9.9 x 10-6	5.0 x 10-9
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	7.6 x 10-2	3.8 x 10-5

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4 x 10-3	9.6 x 10-7
MCW	8.8 x 10-6	3.5 x 10-9
NPA	2.7 x 10-6	1.4 x 10-9
MOI	2.5 x 10-5	1.3 x 10-8
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	1.1 x 10-1	5.3 x 10-5

Table F.1.4.2.1.5-2. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At Savannah River

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.9 x 10-4	1.5 x 10-7
MCW	2.3 x 10-5	8.8 x 10-9
NPA	2.9 x 10-7	1.4 x 10-10
MOI (New ECF)	7.2 x 10-6	3.6 x 10-9
MOI (Barnwell)	1.7 x 10-5	8.6 x 10-9
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	4.1 x 10-2	2.0 x 10-5

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4 x 10-3	9.6 x 10-7
MCW	2.9 x 10-4	1.1 x 10-7
NPA	4.9 x 10-6	2.5 x 10-9

MOI (New ECF)	2.1 x 10-5	1.0 x 10-8
MOI (Barnwell)	1.6 x 10-4	8.1 x 10-8

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 579541	2.5 x 10-1	1.3 x 10-4

Table F.1.4.2.1.5-3. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At Hanford

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.9 x 10-4	1.5 x 10-7
MCW	3.0 x 10-5	1.2 x 10-8
NPA	3.5 x 10-7	1.8 x 10-10
MOI (New ECF)	9.6 x 10-7	4.8 x 10-10
MOI (FMEF)	1.9 x 10-6	9.7 x 10-10

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 375860	6.7 x 10-3	3.4 x 10-6

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4 x 10-3	9.6 x 10-7
MCW	1.9 x 10-4	7.5 x 10-8
NPA	5.5 x 10-6	2.7 x 10-9
MOI (New ECF)	7.0 x 10-6	3.5 x 10-9
MOI (FMEF)	2.4 x 10-5	1.2 x 10-8

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 375860	1.1 x 10-1	5.3 x 10-5

Table F.1.4.2.1.5-4. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At Puget Sound

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1 x 10-4	8.4 x 10-8
MCW	N/A	N/A
NPA	2.5 x 10-4	1.2 x 10-7
MOI	1.4 x 10-4	6.8 x 10-8

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 2975810	3.4 x 10-1	1.7 x 10-4

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4 x 10-3	9.6 x 10-7
MCW	N/A	N/A
NPA	2.9 x 10-3	1.5 x 10-6
MOI	1.6 x 10-3	8.0 x 10-7

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 2975810	1.3	6.4 x 10-4

Table F.1.4.2.1.5-5. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At Pearl Harbor

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.7 x 10-4	3.5 x 10-7
MCW	N/A	N/A
NPA	2.2 x 10-4	1.1 x 10-7
MOI	2.2 x 10-4	1.1 x 10-7
	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 817385	9.0 x 10-1	4.5 x 10-4

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4 x 10-3	9.6 x 10-7
MCW	N/A	N/A
NPA	7.2 x 10-3	3.6 x 10-6
MOI	8.7 x 10-4	4.3 x 10-7
	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 817385	2.4	1.2 x 10-3

Table F.1.4.2.1.5-6. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At Norfolk

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1 x 10-4	8.5 x 10-8
MCW	N/A	N/A
NPA	5.3 x 10-5	2.7 x 10-8
MOI	3.2 x 10-4	1.6 x 10-7
	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 1539002	2.3 x 10-1	1.2 x 10-4

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4 x 10-3	9.6 x 10-7
MCW	N/A	N/A
NPA	6.2 x 10-4	3.1 x 10-7
MOI	3.3 x 10-3	1.7 x 10-6
	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 1539002	1.4	6.9 x 10-4

Table F.1.4.2.1.5-7. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At Portsmouth

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1 x 10-4	8.4 x 10-8
MCW	N/A	N/A
NPA	5.0 x 10-5	2.5 x 10-8
MOI	1.4 x 10-4	7.2 x 10-8
	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 2432627	1.2 x 10-1	6.0 x 10-5

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4 x 10-3	9.6 x 10-7
MCW	N/A	N/A
NPA	1.1 x 10-3	5.6 x 10-7
MOI	1.7 x 10-3	8.7 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	7.9 x 10-1	3.9 x 10-4

Table F.1.4.2.1.5-8. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At Kesselring

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1 x 10-4	8.5 x 10-8
MCW	N/A	N/A
NPA	N/A	N/A
MOI	5.5 x 10-5	2.7 x 10-8
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	2.0 x 10-1	9.8 x 10-5

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4 x 10-3	9.6 x 10-7
MCW	N/A	N/A
NPA	N/A	N/A
MOI	3.5 x 10-4	1.8 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	6.7 x 10-1	3.3 x 10-4

Table F.1.4.2.1.5-9. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At Nevada Test Site

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.4 x 10-4	5.5 x 10-8
MCW	1.1 x 10-7	4.2 x 10-11
NPA	N/A	N/A
MOI	8.5 x 10-6	4.2 x 10-9
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	7.6 x 10-3	3.8 x 10-6

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4 x 10-3	9.6 x 10-7
MCW	6.2 x 10-6	2.5 x 10-9
NPA	N/A	N/A
MOI	4.3 x 10-5	2.2 x 10-8
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	1.1 x 10-2	5.7 x 10-6

Table F.1.4.2.1.5-10. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At Oak Ridge

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.7 x 10-4	3.5 x 10-7
MCW	2.3 x 10-5	8.8 x 10-9
NPA	3.0 x 10-4	1.5 x 10-7
MOI	9.0 x 10-4	4.5 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	1.2 x 10-1	6.0 x 10-5

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4 x 10-3	9.6 x 10-7
MCW	1.4 x 10-4	5.6 x 10-8
NPA	1.9 x 10-3	9.4 x 10-7
MOI	5.7 x 10-3	2.9 x 10-6
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	4.3 x 10-1	2.2 x 10-4

F.1.4.2.1.6 Minor Water Pool Leakage.

F.1.4.2.1.6.1 Description of Conditions. In this hypothetical accident scenario, a minor leak develops in the water pool resulting in a gradual discharge to the environment. There is no danger of uncovering any spent nuclear fuel in the water pool, since the leak is so small that it is undetected and water level is maintained in the water pool. Since a strict accounting of water added to and removed from the water pool is maintained, the magnitude of this leak would be less than 4,400 gallons per year. The 4,400 gallons per year value is the maximum amount of water which might leak out of the water pool before periodic review of the water balance would detect a leak.

F.1.4.2.1.6.2 Source Term. There is no airborne release above normal levels in this hypothetical accident scenario. The radionuclide inventory in the leaking water is based on radioactivity analysis of ECF water pool water. The isotopes that were analyzed for but not detected could exist at the minimum detection limit.

Nuclide	Sample Results (-Ci/mL)	10CFR20 Effluent Limit (-Ci/mL)	Annual Releases (Ci/year)
H-3	2.0 x 10-4	1.0 x 10-3	3.3 x 10-3
Mn-54	2.5 x 10-8	3.0 x 10-5	4.1 x 10-7
Fe-55	1.0 x 10-8 *	1.0 x 10-4	1.6 x 10-7 *
Co-58	7.0 x 10-8	2.0 x 10-5	1.1 x 10-6
Co-60	1.6 x 10-5	3.0 x 10-6	2.6 x 10-5
Ni-63	2.3 x 10-7	1.0 x 10-4	3.8 x 10-6
Sr-90	4.0 x 10-9	5.0 x 10-7	6.5 x 10-8
Y-90	4.0 x 10-9	7.0 x 10-6	6.5 x 10-8
I-129	4.0 x 10-7 *	2.0 x 10-7	6.5 x 10-6 *
Cs-137	4.2 x 10-8	1.0 x 10-6	6.9 x 10-7

* These radionuclides were not detected in the ECF water. The numbers quoted reflect the detection limit of the analysis.

It should be noted that the sample results for the water pool indicate that the nuclide levels are all below the Code of Federal Regulations limits for liquid effluent in 10CFR20 with the exception of Co-60. The level of I-129 used in the calculations was based on the minimum detection limit of the sample. This level exceeds the effluent limit; however, I-129 was not actually detected in the water sample. Since Sr-90 has comparable water solubility to I-129 and exists in spent nuclear fuel at about a factor of 1.0 x 106 higher than I-129, it is inferred from the detected level of Sr-90 that the actual level of I-129 is well below the 10CFR20 effluent limit.

F.1.4.2.1.6.3 Results. The following table summarizes the public health risk to the general

population that might result from the hypothetical minor water pool leak at each location. The number of fatal cancers would be expected to occur over a 50-year period. "Risk" is defined as the number of fatal cancers times the probability of occurrence. The probability of a leak developing is 10-1 per year.

Minor Water Pool Leakage Summary

Site	Maximally exposed off-site individual (MOI) (rem)	No. of fatal cancer if accident occurs	Risk per year
INEL	2.5 x 10-9	1.3 x 10-8	1.3 x 10-9
Savannah River	7.9 x 10-10	1.3 x 10-9	1.3 x 10-10
Hanford	9.9 x 10-12	1.7 x 10-10	1.7 x 10-11
Puget Sound	3.2 x 10-10	4.2 x 10-9	4.2 x 10-10
Pearl Harbor	1.3 x 10-10	4.6 x 10-10	4.6 x 10-11
Norfolk	2.7 x 10-10	1.8 x 10-9	1.8 x 10-10
Portsmouth	1.3 x 10-10	1.4 x 10-9	1.4 x 10-10
Kesselring	6.0 x 10-9	8.5 x 10-9	8.5 x 10-10
Nevada Test Site	2.5 x 10-9	1.4 x 10-9	1.4 x 10-10
Oak Ridge	1.5 x 10-9	3.9 x 10-9	3.9 x 10-10

At all sites except the Nevada Test Site, this accident results in the lowest or next to lowest risk of the wet storage accidents evaluated.

Table F.1.4.2.1.6-1. Summary of Exposure Calculation Results.
For Wet Storage - Minor Water Pool Leakage
At INEL

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	N/A	N/A
MCW	1.6 x 10-13	6.4 x 10-17
NPA	1.6 x 10-13	8.0 x 10-17
MOI	2.5 x 10-9	1.3 x 10-12

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 115690	2.6 x 10-5	1.3 x 10-8

Table F.1.4.2.1.6-2. Summary of Exposure Calculation Results.
For Wet Storage - Minor Water Pool Leakage
At Savannah River

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	N/A	N/A
MCW	4.8 x 10-13	1.9 x 10-16
NPA	4.8 x 10-13	2.4 x 10-16
MOI	7.9 x 10-10	4.0 x 10-13

Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Can-

		cers
Population of 579541	2.5 x 10-6	1.3 x 10-9

Table F.1.4.2.1.6-3. Summary of Exposure Calculation Results.
For Wet Storage - Minor Water Pool Leakage
At Hanford

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	N/A	N/A
MCW	8.3 x 10-15	3.3 x 10-18
NPA	8.3 x 10-15	4.2 x 10-18
MOI	9.9 x 10-12	5.0 x 10-15

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 375860	3.3 x 10-7	1.7 x 10-10

Table F.1.4.2.1.6-4. Summary of Exposure Calculation Results.
For Wet Storage - Minor Water Pool Leakage
At Puget Sound

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	N/A	N/A
MCW	N/A	N/A
NPA	1.2 x 10-11	6.0 x 10-15
MOI	3.2 x 10-10	1.6 x 10-13

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 2975810	8.4 x 10-6	4.2 x 10-9

Table F.1.4.2.1.6-5. Summary of Exposure Calculation Results.
For Wet Storage - Minor Water Pool Leakage
At Pearl Harbor

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	N/A	N/A
MCW	N/A	N/A
NPA	4.8 x 10-12	2.4 x 10-15
MOI	1.3 x 10-10	6.5 x 10-14

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 817385	9.2 x 10-7	4.6 x 10-10

Table F.1.4.2.1.6-6. Summary of Exposure Calculation Results.
For Wet Storage - Minor Water Pool Leakage
At Norfolk

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	N/A	N/A
MCW	N/A	N/A
NPA	9.9 x 10-12	5.0 x 10-15
MOI	2.7 x 10-10	1.4 x 10-13

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 1539002	3.6 x 10-6	1.8 x 10-9

Table F.1.4.2.1.6-7. Summary of Exposure Calculation Results.
For Wet Storage - Minor Water Pool Leakage
At Portsmouth

	Total EDE	Likelihood of Fatal

Location	(rem)	Cancer
Worker	N/A	N/A
MCW	N/A	N/A
NPA	4.8 x 10-12	2.4 x 10-15
MOI	1.3 x 10-10	6.5 x 10-14

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	2.7 x 10-6	1.4 x 10-9

Table F.1.4.2.1.6-8. Summary of Exposure Calculation Results.
For Wet Storage - Minor Water Pool Leakage
At Kesselring

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	N/A	N/A
MCW	N/A	N/A
NPA	N/A	N/A
MOI	6.0 x 10-9	3.0 x 10-12

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	1.7 x 10-5	8.5 x 10-9

Table F.1.4.2.1.6-9. Summary of Exposure Calculation Results.
For Wet Storage - Minor Water Pool Leakage
At Nevada Test Site

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	N/A	N/A
MCW	1.6 x 10-13	6.4 x 10-17
NPA	1.6 x 10-13	8.0 x 10-17
MOI	2.5 x 10-9	1.3 x 10-12

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	2.7 x 10-6	1.4 x 10-9

Table F.1.4.2.1.6-10. Summary of Exposure Calculation Results.
For Wet Storage - Minor Water Pool Leakage
At Oak Ridge

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	N/A	N/A
MCW	9.4 x 10-13	3.8 x 10-16
NPA	9.4 x 10-13	4.7 x 10-16
MOI	1.5 x 10-9	7.5 x 10-13

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	7.7 x 10-6	3.9 x 10-9

F.1.4.2.2 Dry Storage.

F.1.4.2.2.1 Wind-driven Missile Impact into Storage Casks with Mechanical

Damage.

F.1.4.2.2.1.1 Description of Conditions. In this hypothetical accident, no fuel damage

would result from any impact because of the strength of the containers used. Dry storage containers could experience a major wind storm or tornado which could propel a large object into a storage container causing the container seal to be breached. However, container analysis for this situation shows that the container is strong enough to prevent crushing of the spent nuclear fuel and release of fission products.

Winds produced by tornados are higher than hurricane winds and thus the impacting missile would be travelling with higher velocity and would have higher kinetic energy. Even at this higher velocity, analysis has shown that the missile would not penetrate the container. The probability of penetration at the lower velocity of a hurricane (212 miles per hour) would be even smaller than the probability of penetration for a missile propelled by the winds of a tornado (travelling at 360 mph). While hurricanes can have high winds, hurricane winds normally cannot generate the very large, very fast missiles analyzed for tornados. While hurricanes may occur more frequently than tornados, the overall risk from a hurricane is lower because the container would not be penetrated.

The analysis of wind damage using missiles propelled by the winds of tornados is the same as is done for design of nuclear power plants. Hurricanes very infrequently have winds that could generate such missiles, so the analyses provided for tornados provide an upper limit for the effects of hurricanes. Examination of damage caused by recent severe hurricanes shows that robust structures can withstand hurricanes.

F.1.4.2.2.1.2 Source Term. Conditions used in developing the source term are as follows:

- The source term is based on best estimate spent nuclear fuel corrosion products.
- One percent of the original corrosion products associated with the fuel could be released from the cask to the atmosphere. This is based on experimental measurements of the fraction of corrosion products loosened from naval spent nuclear fuel by shock and vibration and the fact that a wind-driven missile would not penetrate the container or damage the fuel inside. Only loose corrosion products would be available for release from the container, and any release from the container would have to occur via a convoluted path through the damaged seal.
- The release to the environment occurs at a constant rate over a 15-minute period.
- There is no increase in direct radiation due to this accident.
- The following amounts of radionuclides could be released to the environment. This listing includes nuclides that result in at least 99% of the possible exposure.

Nuclide	Curies
Co-60	9.58 x 10-2
Fe-55	1.76 x 10-1
Co-58	3.54 x 10-2
Mn-54	5.98 x 10-3
Fe-59	5.11 x 10-4

F.1.4.2.2.1.3 Results. The following table summarizes the public health risk to the general

population that would result from the hypothetical wind-driven missile accident at each location. The number of fatal cancers would be expected to occur over a 50-year period. "Risk" is defined as the number of fatal cancers times the probability of occurrence. The probability of container damage is small due to the very strong container design. The dry storage containers are expected to be designed as well as shipping containers so that they would not be penetrated by environmentally caused missiles and the fuel would not be affected. However, an analysis was performed for a case in which the impact of a tornado missile might topple a container on a railcar and cause unseating of the container seal and thus release radioactive material in the form of corrosion products.

The probability of the occurrence of a tornado was obtained using the data in document WASH-1300 (AEC 1974). The maximum likelihood of a tornado occurrence at all storage locations being evaluated in the continental United States is 10-3 per year. The probability of a missile generated by the tornado striking a container and causing the damage analyzed has been estimated to be less than 10-2. Thus, the total probability of a wind-driven missile damaging a container is less than 10-5, and a probability of 10-5 per year was used in the risk assessment.

Dry Storage Mechanical Damage Summary

Site	Maximally exposed off-site individual (MOI) (rem)	No. of fatal cancer if accident occurs	Risk per year
INEL	4.6 x 10-4	4.9 x 10-4	4.9 x 10-9
Savannah River	4.9 x 10-4	3.0 x 10-3	3.0 x 10-8
Hanford	1.7 x 10-4	1.3 x 10-3	1.3 x 10-8
Puget Sound	3.9 x 10-2	1.7 x 10-2	1.7 x 10-7
Pearl Harbor	2.1 x 10-2	3.0 x 10-2	3.0 x 10-7
Norfolk	8.1 x 10-2	1.8 x 10-2	1.8 x 10-7
Portsmouth	4.2 x 10-2	1.0 x 10-2	1.0 x 10-7
Kesselring	8.1 x 10-3	7.4 x 10-3	7.4 x 10-8
Nevada Test Site	8.8 x 10-4	5.3 x 10-5	5.3 x 10-10
Oak Ridge	1.4 x 10-1	5.1 x 10-3	5.1 x 10-8

The risk for this hypothetical accident is generally more severe at Navy shipyards than at the DOE sites. This accident results in the lowest risk of the two dry storage accidents evaluated.

For the hypothetical wind-driven missile accident scenario, the radioactive plume might cause contamination of the ground to a downwind distance of less than 0.06 mile. This would yield a total area impacted by the accident of less than 0.5 acre. The calculated downwind distance would be contained within the boundaries of all sites under evaluation.

Table F.1.4.2.2.1-1. Summary of Exposure Calculation Results.
For Dry Storage - Mechanical Damage
At INEL

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.0 x 10-2	8.0 x 10-6
MCW	1.8 x 10-5	9.2 x 10-9
NPA	1.0 x 10-5	5.2 x 10-9
MOI	8.0 x 10-5	4.0 x 10-8
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	2.3 x 10-1	1.2 x 10-4

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.6 x 10-2	2.2 x 10-5
MCW	2.0 x 10-4	1.0 x 10-7
NPA	6.3 x 10-5	3.1 x 10-8
MOI	4.6 x 10-4	2.3 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	9.8 x 10-1	4.9 x 10-4

Table F.1.4.2.2.1-2. Summary of Exposure Calculation Results.
For Dry Storage - Mechanical Damage

At Savannah River

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.9 x 10-3	3.6 x 10-6
MCW	5.3 x 10-4	2.1 x 10-7
NPA	6.7 x 10-6	3.4 x 10-9
MOI (New ECF)	1.6 x 10-4	8.1 x 10-8
MOI (Barnwell)	4.0 x 10-4	2.0 x 10-7

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 579541	9.4 x 10-1	4.7 x 10-4

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.6 x 10-2	2.2 x 10-5
MCW	6.7 x 10-3	2.6 x 10-6
NPA	1.1 x 10-4	5.7 x 10-8
MOI (New ECF)	4.9 x 10-4	2.5 x 10-7
MOI (Barnwell)	3.9 x 10-3	2.0 x 10-6

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 579541	6.1	3.0 x 10-3

Table F.1.4.2.2.1-3. Summary of Exposure Calculation Results.
For Dry Storage - Mechanical Damage
At Hanford

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.9 x 10-3	3.6 x 10-6
MCW	7.0 x 10-4	2.8 x 10-7
NPA	8.1 x 10-6	4.1 x 10-9
MOI (New ECF)	2.3 x 10-5	1.1 x 10-8
MOI (FMEF)	4.6 x 10-5	2.3 x 10-8

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 375860	1.4 x 10-1	7.0 x 10-5

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.6 x 10-2	2.2 x 10-5
MCW	4.4 x 10-3	1.8 x 10-6
NPA	1.3 x 10-4	6.3 x 10-8
MOI (New ECF)	1.7 x 10-4	8.4 x 10-8
MOI (FMEF)	5.9 x 10-4	2.9 x 10-7

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 375860	2.5	1.3 x 10-3

Table F.1.4.2.2.1-4. Summary of Exposure Calculation Results.
For Dry Storage - Mechanical Damage
At Puget Sound

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	4.9 x 10-3	1.9 x 10-6
MCW	N/A	N/A
NPA	5.7 x 10-3	2.9 x 10-6
MOI	3.5 x 10-3	1.7 x 10-6

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2975810	1.2 x 101	5.8 x 10-3

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.6 x 10-2	2.2 x 10-5
MCW	N/A	N/A
NPA	6.8 x 10-2	3.4 x 10-5
MOI	3.9 x 10-2	1.9 x 10-5

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2975810	3.4 x 101	1.7 x 10-2

Table F.1.4.2.2.1-5. Summary of Exposure Calculation Results.
For Dry Storage - Mechanical Damage
At Pearl Harbor

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.0 x 10-2	8.0 x 10-6
MCW	N/A	N/A
NPA	5.2 x 10-3	2.6 x 10-6
MOI	5.3 x 10-3	2.7 x 10-6

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	2.2 x 101	1.1 x 10-2

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.6 x 10-2	2.2 x 10-5
MCW	N/A	N/A
NPA	1.7 x 10-1	8.4 x 10-5
MOI	2.1 x 10-2	1.1 x 10-5

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	5.9 x 101	3.0 x 10-2

Table F.1.4.2.2.1-6. Summary of Exposure Calculation Results.
For Dry Storage - Mechanical Damage
At Norfolk

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	4.9 x 10-3	2.0 x 10-6
MCW	N/A	N/A
NPA	1.2 x 10-3	6.2 x 10-7
MOI	7.8 x 10-3	3.9 x 10-6

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	7.4	3.7 x 10-3

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.6 x 10-2	2.2 x 10-5
MCW	N/A	N/A
NPA	1.4 x 10-2	7.1 x 10-6
MOI	8.1 x 10-2	4.0 x 10-5

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	3.5 x 101	1.8 x 10-2

Table F.1.4.2.2.1-7. Summary of Exposure Calculation Results.
For Dry Storage - Mechanical Damage
At Portsmouth

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	4.9 x 10-3	1.9 x 10-6
MCW	N/A	N/A
NPA	1.2 x 10-3	5.8 x 10-7
MOI	3.5 x 10-3	1.8 x 10-6
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	4.2	2.1 x 10-3

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.6 x 10-2	2.2 x 10-5
MCW	N/A	N/A
NPA	2.6 x 10-2	1.3 x 10-5
MOI	4.2 x 10-2	2.1 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	2.0 x 101	1.0 x 10-2

Table F.1.4.2.2.1-8. Summary of Exposure Calculation Results.
For Dry Storage - Mechanical Damage
At Kesselring

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	4.9 x 10-3	2.0 x 10-6
MCW	N/A	N/A
NPA	N/A	N/A
MOI	8.8 x 10-4	4.4 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	3.3	1.7 x 10-3

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.6 x 10-2	2.2 x 10-5
MCW	N/A	N/A
NPA	N/A	N/A
MOI	8.1 x 10-3	4.0 x 10-6
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	1.5 x 101	7.4 x 10-3

Table F.1.4.2.2.1-9. Summary of Exposure Calculation Results.
For Dry Storage - Mechanical Damage
At Nevada Test Site

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.2 x 10-3	1.3 x 10-6

MCW	2.5 x 10-6	9.6 x 10-10
NPA	N/A	N/A
MOI	4.5 x 10-5	2.2 x 10-8
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	1.5 x 10-2	7.3 x 10-6

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.6 x 10-2	2.2 x 10-5
MCW	1.4 x 10-4	5.8 x 10-8
NPA	N/A	N/A
MOI	8.8 x 10-4	4.4 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	1.1 x 10-1	5.3 x 10-5

Table F.1.4.2.2.2.1-10. Summary of Exposure Calculation Results.
For Dry Storage - Mechanical Damage
At Oak Ridge

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.0 x 10-2	8.0 x 10-6
MCW	5.3 x 10-4	2.1 x 10-7
NPA	6.9 x 10-3	3.4 x 10-6
MOI	2.2 x 10-2	1.1 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	2.8	1.4 x 10-3

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.6 x 10-2	2.2 x 10-5
MCW	3.2 x 10-3	1.3 x 10-6
NPA	4.4 x 10-2	2.2 x 10-5
MOI	1.4 x 10-1	6.9 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	1.0 x 101	5.1 x 10-3

F.1.4.2.2.2 Airplane Crash.

F.1.4.2.2.2.1 Description of Conditions. A hypothetical aircraft accident scenario was developed for the dry storage option. Based on the probability of occurrence, as discussed in Section F.3, specific analyses were only performed for Savannah River, Oak Ridge, Pearl Harbor, Norfolk, Portsmouth, and Kesselring locations. At other locations, the likelihood of occurrence is less than 10-7 per year. The accident is postulated to cause damage to a single storage cask. This is based on the fact that containers used to store naval spent nuclear fuel would be very rugged so that only the rotor shaft from one of an airliner's jet engines would be strong enough and possess enough energy to have a chance of penetrating a container. From analyses of existing container designs, the rotor of a large jet engine, including those from the largest aircraft such as a Boeing 777, Russian Antonov An-225, or a Lockheed C-5, would not penetrate a container during an airliner crash, but, for the purposes of evaluation, calculations were performed for one container damaged to the extent that fission products and corrosion products might be released. Due to the severity of the shock, the cask seal might be breached resulting in damage to the fuel. The severe mechanical shock results in the release of corrosion products to the environment. The release of fission products also occurs due to the impact and resultant fire. The fission product release factors are based on overheating testing performed on the naval fuel systems.

F.1.4.2.2.2.2 Source Term. Conditions used in developing the source term are as follows:

- One percent of all of the fuel units stored inside the cask are damaged either by the impact or the resultant fire and those fission products are available for release.
- Of the available fission products, 100% of the noble gases, 3% of the halogens, 1.1% of the cesium, and 0.1% of the remaining solids are released to the environment.
- The release to the environment occurs at a constant rate over a 15-minute period.
- Ten percent of the original corrosion products from the fuel units are released from the cask to the atmosphere.
- The following amount of radionuclides could be released to the environment. This listing includes nuclides that result in at least 99% of the possible exposure.

Nuclide	Curies
Cs-134	2.57 x 101
Cs-137	3.56 x 101
Pu-238	5.90 x 10-2
Ba-137M	3.07
Sr-90	3.12
Ce-144	7.17
Nb-95	4.37
Y-90	3.12
Ru-106	6.11 x 10-1

F.1.4.2.2.2.3 Results. The following table summarizes the public health risk to the general population that would result from the hypothetical airplane crash accident at each location. The number of fatal cancers would be expected to occur over a 50-year period. "Risk" is defined as the number of fatal cancers times the probability of occurrence.

Dry Storage Airplane Crash Summary

Site	Probability of accident per year	Maximally exposed off-site individual (MOI) (rem)	No. of fatal cancers if accident occurs	Risk per year
Savannah River	3 x 10-7	4.7 x 10-1	2.8	8.4 x 10-7
Pearl Harbor	1 x 10-5	19	26	2.6 x 10-4
Norfolk	1 x 10-6	72	16	1.6 x 10-5
Portsmouth	1 x 10-7	38	9.0	9.0 x 10-7
Kesselring	1 x 10-7	7.7	7.5	7.5 x 10-7
Oak Ridge	3 x 10-7	120	4.7	1.4 x 10-6

The risk for this hypothetical accident is most severe at Pearl Harbor and Norfolk. It is also the highest risk for any hypothetical accident evaluated at Pearl Harbor and Norfolk. For the sites with crash probabilities less than 10-7 per year, consequences were not calculated since it is expected that they would not substantially contribute to the risk.

For the hypothetical airplane crash into a dry storage cask accident scenario, the radioactive plume might cause contamination of the ground to a downwind distance of approximately 0.9 mile. This would yield a total area impacted by the accident of about 106 acres. The calculated downwind distance would be contained within the boundaries of the Savannah River and Kesselring sites. The contaminated plume would extend beyond the boundaries of Oak Ridge and the shipyards that are at risk for this accident.

Table F.1.4.2.2.2-1. Summary of Exposure Calculation Results.
Dry Storage - Airplane Crash
At Savannah River

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.5 x 101	5.9 x 10-3
MCW	8.7 x 10-1	3.5 x 10-4
NPA	1.1 x 10-2	5.5 x 10-6
MOI	1.8 x 10-1	8.8 x 10-5
	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 579541	9.6 x 102	4.8 x 10-1

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	9.2 x 101	7.4 x 10-2
MCW	1.1 x 101	4.4 x 10-3
NPA	1.9 x 10-1	9.5 x 10-5
MOI	4.7 x 10-1	2.3 x 10-4
	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 579541	5.5 x 103	2.8

Table F.1.4.2.2.2-2. Summary of Exposure Calculation Results.
Dry Storage - Airplane Crash
At Pearl Harbor

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.3 x 101	2.7 x 10-2
MCW	N/A	N/A
NPA	8.6	4.3 x 10-3
MOI	4.7	2.3 x 10-3
	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 817385	2.0 x 104	9.8

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	9.2 x 101	7.4 x 10-2
MCW	N/A	N/A
NPA	2.8 x 102	2.8 x 10-1
MOI	1.9 x 101	9.3 x 10-3
	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 817385	5.2 x 104	2.6 x 101

Table F.1.4.2.2.2-3. Summary of Exposure Calculation Results.
Dry Storage - Airplane Crash
At Norfolk

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.2	3.3 x 10-3
MCW	N/A	N/A
NPA	2.0	1.0 x 10-3
MOI	6.9	3.4 x 10-3

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	6.5 x 103	3.2

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	9.2 x 101	7.4 x 10-2
MCW	N/A	N/A
NPA	2.4 x 101	2.4 x 10-2
MOI	7.2 x 101	7.2 x 10-2

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	3.1 x 104	1.6 x 101

Table F.1.4.2.2.2-4. Summary of Exposure Calculation Results.
Dry Storage - Airplane Crash
At Portsmouth

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.1	3.2 x 10-3
MCW	N/A	N/A
NPA	1.9	9.6 x 10-4
MOI	3.1	1.6 x 10-3

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	3.7 x 103	1.9

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	9.2 x 101	7.4 x 10-2
MCW	N/A	N/A
NPA	4.3 x 101	4.3 x 10-2
MOI	3.8 x 101	3.8 x 10-2

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	1.8 x 104	9.0

Table F.1.4.2.2.2-5. Summary of Exposure Calculation Results.
Dry Storage - Airplane Crash
At Kesselring

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.2	3.3 x 10-3
MCW	N/A	N/A
NPA	N/A	N/A
MOI	1.3	6.6 x 10-4

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	4.8 x 103	2.4

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	9.2 x 101	7.4 x 10-2
MCW	N/A	N/A
NPA	N/A	N/A
MOI	7.7	3.8 x 10-3
	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 1148587	1.5 x 104	7.5

Table F.1.4.2.2.2-6. Summary of Exposure Calculation Results. Dry Storage - Airplane Crash At Oak Ridge

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.3 x 101	2.7 x 10-2
MCW	8.7 x 10-1	3.5 x 10-4
NPA	1.1 x 101	5.7 x 10-3
MOI	1.9 x 101	9.7 x 10-3
	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 871531	2.9 x 103	1.4

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	9.2 x 101	7.4 x 10-2
MCW	5.3	2.2 x 10-3
NPA	7.2 x 101	7.2 x 10-2
MOI	1.2 x 102	1.2 x 10-1
	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 871531	9.5 x 103	4.7

F.1.4.2.3 Dry Cell Operations.

F.1.4.2.3.1 Inadvertent Cutting into Fuel Region or Mechanical Damage.

F.1.4.2.3.1.1 Description of Conditions. Mechanical damage due to handling during

examination, such as accidentally cutting into the fuel region of an element, was assessed. This hypothetical accident results from inadvertent cutting across the fuel region when cropping off the Zircaloy ends of a fuel unit. All noble gas isotopes within the vicinity of the cut might be released to the facility building and escape to the environment. The majority of the volatile and solid nuclides are likely to be retained in the fuel or the facility exhaust filters. The resulting airborne release to the environment was evaluated. The possible exposure to the workers, individuals living on the site boundary, and the general population was evaluated.

F.1.4.2.3.1.2 Source Term. Conditions used in developing the source term are as follows:

- One percent of the fission products in the fuel element being handled are close enough to the cut site to be available for release.
- All (100%) of the noble gases available for release are released to the atmosphere.
- Twenty-five percent of the halogens available for release are released.
- One percent of the particulate fission products could be released and 99.9% of these are removed by normally installed HEPA filters.
- Cs and Ru would behave like particulate fission products.
- The release to the environment occurs at a constant rate over a 15-minute period.
- There is no increase in direct radiation due to this accident.
- The following amounts of radionuclides could be released to the environment. This listing includes nuclides that result in at least 99% of the possible exposure.

Nuclide	Curies
Pu-238	7.2 x 10-5
Cs-134	2.9 x 10-3
Cs-137	4 x 10-3
I-129	2.5 x 10-5
Sr-90	3.9 x 10-3
Ce-144	9.0 x 10-3
Nb-95	5.4 x 10-3
I-131	5.4 x 10-4
H-3	1.42
Y-90	3.9 x 10-3
Ba-137m	3.8 x 10-3
Ru-106	7.6 x 10-4
Zr-95	2.9 x 10-3
Y-91	2.3 x 10-3
Eu-154	2.7 x 10-4

F.1.4.2.3.1.3 Results. The following table summarizes the public health risk to the general

population that would result from the hypothetical mechanical damage accident at each location. The number of fatal cancers would be expected to occur over a 50-year period. "Risk" is defined as the number of fatal cancers times the probability of occurrence. The probability of damage to fuel during handling is small. The work on fuel at the INEL-ECF includes removal of the non-fueled portions at each end of the fuel unit. This is done in a sawing operation. To cut into the fuel, there must be operator error in positioning the spent fuel in the cutting apparatus and error in selecting the saw cut positioning gage. The combined operator and independent checker error probability for cutting of the fuel has been evaluated to be less than 10-7 per cut (Swain and Guttman 1983). Using a conservative number of 103 saw cut operations per year results in a fuel cutting probability of less than 10-4 per year which has been used in the risk evaluation.

Dry Cell Mechanical Damage Summary

Site	Maximally exposed off-site individual (MOI) (rem)	No. of fatal cance if accident occurs	Risk per year
INEL	2.2 x 10-4	3.5 x 10-4	3.5 x 10-8
Savannah River	2.4 x 10-4	1.4 x 10-3	1.4 x 10-7
Hanford	7.1 x 10-5	5.3 x 10-4	5.3 x 10-8
Nevada Test Site	4.0 x 10-4	3.7 x 10-5	3.7 x 10-9
Oak Ridge	5.8 x 10-2	2.5 x 10-3	2.5 x 10-7

The risk for this hypothetical accident is roughly proportional to the surrounding population with Oak Ridge being the worst and the Nevada Test Site being the best.

For the hypothetical dry cell mechanical damage accident scenario, the radioactive plume might result in contamination of the ground to a downwind distance of less than 0.06 mile. This would yield a total area impacted by the accident of less than 0.5 acre. The calculated downwind distance would be contained within the boundaries of all DOE sites under evaluation.

Table F.1.4.2.3.1-1. Summary of Exposure Calculation Results.
For Dry Cell Operations - Mechanical Damage
At INEL

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.7 x 10-2	1.5 x 10-5
MCW	3.4 x 10-5	1.4 x 10-8
NPA	1.9 x 10-5	9.5 x 10-9
MOI	6.2 x 10-5	3.1 x 10-8
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	3.9 x 10-1	1.9 x 10-4

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.0 x 10-1	4.1 x 10-5
MCW	3.7 x 10-4	1.5 x 10-7
NPA	1.1 x 10-4	5.7 x 10-8
MOI	2.2 x 10-4	1.1 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	7.0 x 10-1	3.5 x 10-4

Table F.1.4.2.3.1-2. Summary of Exposure Calculation Results.
For Dry Cell Operations - Mechanical Damage
At Savannah River

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.6 x 10-2	6.6 x 10-6
MCW	9.6 x 10-4	3.8 x 10-7
NPA	1.2 x 10-5	6.1 x 10-9
MOI (New ECF)	1.0 x 10-4	5.1 x 10-8
MOI (Barnwell)	2.0 x 10-4	1.0 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	6.2 x 10-1	3.1 x 10-4

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.0 x 10-1	4.1 x 10-5
MCW	1.2 x 10-2	4.9 x 10-6
NPA	2.1 x 10-4	1.0 x 10-7
MOI (New ECF)	2.4 x 10-4	1.2 x 10-7
MOI (Barnwell)	1.7 x 10-3	8.4 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	2.8	1.4 x 10-3

Table F.1.4.2.3.1-3. Summary of Exposure Calculation Results.
For Dry Cell Operations - Mechanical Damage
At Hanford

50% METEOROLOGY

Likelihood

Location	Total EDE (rem)	of Fatal Cancer
Worker	1.6 x 10-2	6.6 x 10-6
MCW	1.3 x 10-3	5.1 x 10-7
NPA	1.5 x 10-5	7.4 x 10-9
MOI (New ECF)	9.8 x 10-6	4.9 x 10-9
MOI (FMEF)	2.0 x 10-5	9.9 x 10-9

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375860	6.2 x 10-2	3.1 x 10-5

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.0 x 10-1	4.1 x 10-5
MCW	8.0 x 10-3	3.2 x 10-6
NPA	2.3 x 10-4	1.2 x 10-7
MOI (New ECF)	7.1 x 10-5	3.6 x 10-8
MOI (FMEF)	2.5 x 10-4	1.2 x 10-7

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375860	1.07	5.3 x 10-4

Table F.1.4.2.3.1-4. Summary of Exposure Calculation Results.
For Dry Cell Operations - Mechanical Damage
At Nevada Test Site

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.8 x 10-3	2.3 x 10-6
MCW	4.5 x 10-6	1.8 x 10-9
NPA	N/A	N/A
MOI	4.7 x 10-5	2.3 x 10-8

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	3.6 x 10-2	1.8 x 10-5

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.0 x 10-1	4.1 x 10-5
MCW	2.6 x 10-4	1.0 x 10-7
NPA	N/A	N/A
MOI	4.0 x 10-4	2.0 x 10-7

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	7.4 x 10-2	3.7 x 10-5

Table F.1.4.2.3.1-5. Summary of Exposure Calculation Results.
For Dry Cell Operations - Mechanical Damage
At Oak Ridge

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.7 x 10-2	1.5 x 10-5
MCW	9.6 x 10-4	3.8 x 10-7
NPA	1.3 x 10-2	6.3 x 10-6
MOI	9.3 x 10-3	4.6 x 10-6

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	1.9	9.5 x 10-4

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.0 x 10-1	4.1 x 10-5
MCW	5.9 x 10-3	2.4 x 10-6
NPA	8.0 x 10-2	4.0 x 10-5
MOI	5.8 x 10-2	2.9 x 10-5
	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 871531	5.1	2.5 x 10-3

F.1.4.2.3.2 Partial Loss of Shielding Due to Earthquake.

F.1.4.2.3.2.1 Description of Conditions. A hypothetical earthquake causes the proposed

Dry Cell Facility to lose some portion of its concrete shielding. Direct radiation exposure to the on-site work force and the general public has been calculated.

F.1.4.2.3.2.2 Source Term. The conditions used to calculate the dry cell direct radiation

levels are as follows:

- For calculational purposes, a total of 50% of the high-density concrete dry cell shielding might be removed due to the earthquake. More realistic damage from an earthquake would result in cracks or small openings in the shielding. This bounds anticipated damage to the facility.

- Building containment and ventilation systems remain in operation. Therefore, there is no airborne release to the environment. Calculations have already been performed in Section F.1.4.2.1.1 for a drained water pool hypothetical accident which bound any anticipated airborne releases from the dry cell facility should the building containment and ventilation systems fail.

F.1.4.2.3.2.3 Results. The following table summarizes the public health risk to the general

population that would result from the hypothetical loss of shielding accident at each location. The number of fatal cancers would be expected to occur over a 50-year period. "Risk" is defined as the number of fatal cancers times the probability of occurrence. As discussed in Section F.1.4.2.1.1.3, the probability of this hypothetical accident is estimated to be 10-5 per year.

Dry Cell Partial Loss of Shielding Summary

Site	Maximally exposed off-site individual (MOI) (rem)	No. of fatal cance if accident occurs	Risk per year
INEL	9.3 x 10-17	3.0 x 10-19	3.0 x 10-24
Savannah River	6.7 x 10-15	3.0 x 10-16	3.0 x 10-21
Hanford	3.3 x 10-23	4.9 x 10-24	4.9 x 10-29
Nevada Test Site	6.3 x 10-11	3.7 x 10-37	3.7 x 10-42
Oak Ridge	1.2 x 10-2	7.5 x 10-6	7.5 x 10-11

At all sites, the risks associated with this accident are the lowest of any accident evaluated.

Table F.1.4.2.3.2-1. Summary of Exposure Calculation Results.
For Dry Cell Operations - Partial Loss of Shielding
At INEL

Receptor Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.2 x 10-5	2.9 x 10-8
MCW	7.5 x 10-13	3.0 x 10-16
MOI	9.3 x 10-17	4.7 x 10-20

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 115,690	5.9 x 10-16	3.0 x 10-19

Table F.1.4.2.3.2-2. Summary of Exposure Calculation Results.
For Dry Cell Operations - Partial Loss of Shielding
At Savannah River

Receptor Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.2 x 10-5	2.9 x 10-8
MCW	2.7 x 10-6	1.1 x 10-9
MOI (New ECF)	6.7 x 10-15	3.4 x 10-18
MOI (Barnwell Plant)	2.4 x 10-6	1.2 x 10-9
NPA	7.9 x 10-17	4.0 x 10-20

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 579,541	5.9 x 10-13	3.0 x 10-16

Table F.1.4.2.3.2-3. Summary of Exposure Calculation Results.
For Dry Cell Operations - Partial Loss of Shielding
At Hanford

Receptor Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.2 x 10-5	2.9 x 10-8
MCW	2.7 x 10-6	1.1 x 10-9
MOI (New ECF)	3.3 x 10-23	1.7 x 10-26
MOI (FMEF)	6.7 x 10-15	3.4 x 10-18
NPA	3.9 x 10-25	2.0 x 10-28

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 375,860	9.7 x 10-21	4.9 x 10-24

Table F.1.4.2.3.2-4. Summary of Exposure Calculation Results.
For Dry Cell Operations - Partial Loss of Shielding
At Nevada Test Site

Receptor Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.2 x 10-5	2.9 x 10-8
MCW	7.1 x 10-15	2.8 x 10-18
MOI	6.3 x 10-11	3.2 x 10-14

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 12,159	8.7 x 10-33	4.4 x 10-36

Table F.1.4.2.3.2-5. Summary of Exposure Calculation Results.
For Dry Cell Operations - Partial Loss of Shielding
At Oak Ridge

Receptor Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.2 x 10-5	2.9 x 10-8
MCW	5.5 x 10-7	2.2 x 10-10

MOI	1.2 x 10-2	6.0 x 10-6
NPA	1.4 x 10-4	7.0 x 10-8

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 871,531	1.5 x 10-2	7.5 x 10-6

F.1.4.2.3.3 Airplane Crash Into Dry Cell Facility.

F.1.4.2.3.3.1 Description of Conditions. A hypothetical aircraft accident scenario was developed for dry cell operations. Based on the probability of occurrence, as discussed in Section F.3, specific analysis was only performed for Savannah River, the Nevada Test Site, and Oak Ridge. The accident was postulated to cause major damage to the building, resulting in the loss of containment and filtered exhaust systems. The fuel units inside the dry cell could also be damaged due to mechanical impacts and potential fire. The fission products which might be released are based on factors derived from overheating testing performed on the naval fuel systems. The mechanical impact also could result in the release of corrosion products to the environment.

F.1.4.2.3.3.2 Source Term. The development of the radioactive source term for this scenario is based on the following:

- One percent of the fuel units stored inside of the dry cell might be damaged by either the impact or resultant fire and those fission products would be available for release.
- Of the fission products available for release, 100% of the noble gases, 3% of the halogens, 1.1% of the cesium, and 0.1% of the remaining solids could be released to the environment.
- The release to the environment would occur at a constant rate over a 15-minute period.
- 10% of the available corrosion products could be released to the environment.
- A portion of the concrete shielding is destroyed; however, the resultant rubble provides a minimum of 6 inches of concrete shielding.
- The following amount of radionuclides could be released to the environment. This listing includes nuclides that result in at least 99% of the possible exposure.

Nuclide	Curies
Cs-134	4.5 x 101
Cs-137	6.23 x 101
Pu-238	1.03 x 10-1
BA-137M	5.37
Sr-90	5.46
Ce-144	1.25 x 101
Nb-95	7.65
Y-90	5.46
Ru-106	1.07

F.1.4.2.3.3.3 Results. The following table summarizes the public health risk to the general population that would result from the hypothetical airplane crash into the dry cell at the Savannah River Site. The number of fatal cancers would be expected to occur over a 50-year period. "Risk" is defined as the number of fatal cancers times the probability of occurrence.

Site	Probability of accident per year	Maximally exposed off-site individual (MOI) (rem)	No. of fatal cancers if accident occurs	Risk per year
Savannah River	2 x 10-6	8.2 x 10-1	4.8	9.6 x 10-6
Nevada Test Site	4 x 10-7	1.6	1.8 x 10-1	7.2 x 10-8
Oak Ridge	1 x 10-6	350	8.4	8.4 x 10-6

This accident results in the highest risk for any hypothetical accident evaluated at Savannah River, the Nevada Test Site, and Oak Ridge.

For the hypothetical airplane crash into a dry cell accident scenario, the radioactive plume might cause contamination of the ground to a downwind distance of approximately 1.3 miles. This would yield a total area impacted by the accident of about 207 acres. The calculated downwind distance would be contained within the boundaries of Savannah River and the Nevada Test Site, but not Oak Ridge.

Table F.1.4.2.3.3-1. Summary of Exposure Calculation Results.
For Dry Cell Operations - Airplane Crash
At Savannah River

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.6 x 101	2.1 x 10-2
MCW	1.6	6.2 x 10-4
NPA	1.9 x 10-2	9.6 x 10-6
MOI	3.1 x 10-1	1.5 x 10-4

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	1.6 x 103	8.1 x 10-1

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.6 x 102	1.3 x 10-1
MCW	1.9 x 101	7.8 x 10-3
NPA	3.3 x 10-1	1.7 x 10-4
MOI	8.2 x 10-1	4.1 x 10-4

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	9.6 x 103	4.8

Table F.1.4.2.3.3-2. Summary of Exposure Calculation Results.
For Dry Cell Operations - Airplane Crash
At Nevada Test Site

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	9.2	3.7 x 10-3
MCW	7.1 x 10-3	2.9 x 10-6
NPA	N/A	N/A
MOI	2.5 x 10-1	1.3 x 10-4

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	2.1 x 102	1.1 x 10-1

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.6 x 102	1.3 x 10-1

MCW	4.2 x 10-1	1.7 x 10-4
NPA	N/A	N/A
MOI	1.6	8.0 x 10-4
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	3.5 x 102	1.8 x 10-1

Table F.1.4.2.3.3-3. Summary of Exposure Calculation Results.
For Dry Cell Operations - Airplane Crash
At Oak Ridge

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.8 x 101	4.7 x 10-2
MCW	1.5	6.2 x 10-4
NPA	2.2 x 101	2.2 x 10-2
MOI	1.7 x 102	1.7 x 10-1
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	5.2 x 103	2.6

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.6 x 102	1.3 x 10-1
MCW	9.3	4.7 x 10-3
NPA	1.3 x 102	1.3 x 10-1
MOI	3.5 x 102	3.5 x 10-1
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	1.7 x 104	8.4

F.1.4.3 Impact of Accidents on Close-in Workers. An evaluation has been made of the impact to

close-in workers involved in naval spent nuclear fuel management that might occur due to the various radiological accidents postulated in spent fuel handling. This evaluation focused on the radiological consequences of the accident. Clearly, a limited number of fatalities may occur which are related to spent fuel handling only in a secondary manner; i.e., the worker who happened to be in the facility may be killed due to a plane crash, seismic event, crane failure, etc. These secondary effects are not discussed in the following. Rather, only radiological consequences are considered.

F.1.4.3.1 Wet Storage.

F.1.4.3.1.1 Drained Water Pool Due to Seismic Event. No fatalities to workers close to

the scene of the accident would be expected due to radiological consequences. This is because drainage of the large amount of water in a water pool is expected to take several days which provides ample time for workers to leave the facility.

F.1.4.3.1.2 Accidental Criticality in a Water Pool Due to Human Error. It is likely no

fatalities would occur. At most, two or three workers may receive some appreciable radiation exposure. This is because the criticality would occur under approximately 20 feet of water. Shielding by the water would be sufficient to prevent exposure of nearby workers. Expulsion of a cone of water above the criticality might lead to significant exposure to any workers who were directly above the location of the criticality.

F.1.4.3.1.3 Mechanical Damage to Fuel in a Water Pool Due to Operator Error or

Crane Failure. No fatalities to workers would be expected from radiological consequences. This is because the release of the source term is underwater. Attenuation by the water would occur for most products, but release of noble gases would cause a direct radiation exposure to workers in the area. Upon releases from the surface of the water pool, radiation alarms would sound requiring evacuation of nearby workers. Timely evacuation would prevent substantial radiation exposure.

F.1.4.3.1.4 Airplane Crash into Water Pool Storage. No fatalities to workers would be

expected from radiological consequences. This is because any release of radioactive products would be underwater and radiation alarms would sound requiring evacuation of nearby workers. Timely evacuation would prevent substantial radiation exposure.

F.1.4.3.2 Dry Storage.

F.1.4.3.2.1 Wind-driven Missile Impact on Storage Casks. It is likely there would be no

fatalities to workers from radiological consequences. This is because there usually would be no nearby workers except for brief periods when a container is being placed in the dry storage array. Since a wind-driven missile is not expected to penetrate a dry storage container, direct radiation exposures even to nearby workers would not be expected. The container seal could be breached and some airborne products released. At most, two or three nearby workers may receive some radiation exposure from inhalation of airborne radioactivity.

F.1.4.3.2.2 Airplane Crash into Dry Storage. It is not likely that any fatalities would occur

to nearby workers due to the radiological consequences of this accident. As in Section F.1.4.3.2.1 above, workers are usually not in the dry storage array except when a container is being placed into the array. At most, two or three nearby workers might receive significant radiation exposure from inhalation of airborne radioactivity since the container seal may be breached. The low probability of the airplane crash itself, coupled with the probability that workers would be close enough to be affected, coupled with the probability that the wind would be blowing in the direction of the workers, makes it very unlikely that any worker would receive substantial radiation exposure.

F.1.4.3.3 Dry Cell Operations.

F.1.4.3.3.1 Inadvertent Cutting into Fuel or Mechanical Damage. No fatalities to

workers would be expected from the radiological consequences of this accident. This is because the ventilation systems' exhaust from a dry cell is directed to the outside of the building in which a dry cell is constructed and away from nearby workers.

F.1.4.3.3.2 Partial Loss of Shielding of a Dry Cell. It is likely that no fatalities would

occur among nearby workers from the radiological consequences of this accident. This is because there is still substantial shielding of radiation from material inside the cell even with the assumed 50-percent loss of the high-density concrete. However, one or two nearby workers may receive some exposure from radiation streaming through a crack in the dry cell if this is the mode of failure. Workers are trained to evacuate quickly when radiation alarms sound.

F.1.4.3.4 Other Accidents.

F.1.4.3.4.1 HEPA Filter Fire. No fatalities would be expected among nearby workers from the

radiological consequences of a fire in a HEPA filter. This is because HEPA filters are not located in an area where workers are likely to be working. In addition, the release of radioactivity involved in a HEPA filter fire is not large.

F.1.4.3.4.2 Small Leaks from Water Pools. No fatalities are expected among nearby

workers from the radiological consequences of a small leak from a water pool. The leak would be expected to be into the ground through the water pathway. Drinking water supplies would not be immediately impacted. In addition, the typical concentration of radioactivity in the water is low.

F.1.4.4 Evaluation of Shipboard Fire Involving Shipping Containers.

F.1.4.4.1 Description of Conditions. In this hypothetical accident scenario, a fire onboard a

ship that is transporting naval spent nuclear fuel in shipping containers from Pearl Harbor to Puget Sound is postulated. This accident could be initiated by a collision with another ship. The collision and subsequent fire are postulated to occur in Puget Sound in the center of the shipping lane at a distance of approximately 2 miles from Seattle. The consequences of a similar accident at Pearl Harbor would be less because of the smaller population and the fact that Pearl Harbor is a restricted area and is very close to the sea on the south side, limiting the number of people who might be exposed. This section addresses the radiological consequences of this postulated accident scenario. The toxic chemical consequences related to the burning fuel oil are presented in Section F.2.4.2.2.

During shipment, the containers are well protected from direct mechanical damage should a ship collision occur. The rugged nature of the shipping container and the naval reactor's fuel system is demonstrated by the analysis of airplane crashes which showed that a jet engine rotor would not penetrate the container or rupture the fuel. A severe fire is necessary to potentially cause failure of the container seals and overheat the spent fuel sufficiently to release fission products. Collisions of this severity are extremely unlikely. During the hypothetical accident, the fire would need to burn intensely in the hold for several hours to cause release of fission products or corrosion products to the environment.

F.1.4.4.2 Source Term. Conditions used in developing the source term are as follows:

- Ten percent of all fuel unit cladding inside of two shipping containers is ruptured and the contained fission products are available to be released from the fuel units.
- Of the available fission products, 100% of the noble gases, 3% of the halogens, 1.1% of the cesium, and 0.1% of the remaining solid fission products are assumed to be released to the container.
- Ten percent of all fission products released to the container are released to the environment and the remainder are adherent on the fuel and cask surfaces.
- Ten percent of the original corrosion products from the fuel units are released from the cask to the environment.
- The following amount of radionuclides could be released to the environment. This listing includes nuclides from one container that result in at least 99% of the possible exposure.

Nuclide	Curies
Cs-134	2.57 x 101
Cs-137	3.56 x 101
Pu-238	5.90 x 10-2
Ba-137M	3.07
Sr-90	3.12
Ce-144	7.17
Nb-95	4.37
Y-90	3.12
Ru-106	6.11 x 10-1

F.1.4.4.3 Results. The following table summarizes the public health risk to the general population that would result from the hypothetical shipboard fire accident. The number of fatal cancers would be expected to occur over a 50-year period. "Risk" is defined as the number of fatal cancers times the probability of occurrence.

The probability of occurrence of this hypothetical shipping accident is 6.7 x 10-8 per year or less, and was obtained as follows. The probability of a single port entry accident is 1.6 x 10-4 (DOE 1994). The probability of a fire, given the occurrence of an accident, is 8 x 10-4 (DOE 1994). Combining these two probabilities with the port entry frequency of 21 naval spent nuclear fuel shipments spread over 40 years results in a probability of 6.7 x 10-8 per year. Due to the rugged nature of the naval fuel and likely effectiveness of fire fighting over a several hour period, the probability of fission product release to the environment would be even less.

DOE guidance (DOE 1993b) provides that the consequence of an accident which has a probability of occurrence of less than 1 x 10-7 per year need not be calculated. However, in view of interest in this accident expressed in several public comments, the following table is provided listing both the consequence and the risk.

Shipboard Fire Involving Shipping Containers

In Puget Sound Shipping Lane	50% Meteorology		95% Meteorology	
Maximally Exposed Off-site Individual (MOI)	Total EDE (Rem)	Likelihood of Fatal Cancer	Total EDE (Rem)	Likelihood of Fatal Cancer
	9.3 x 10-1	4.7 x 10-4	1.8	9.2 x 10-4
General Population within 50-mile Radius	Exposure (Person-Rem)	Number of Fatal Cancers	Exposure (Person-Rem)	Number of Fatal Cancers
	2.27 x 104	11.4	1.03 x 105	51.5
Risk per year	7.6 x 10-7		3.5 x 10-6	

The risk for this hypothetical accident is slightly lower than that for the most severe facility accident analyzed at Puget Sound.

For the hypothetical shipboard fire accident, the radioactive plume might cause contamination to a downwind distance of less than 1 mile. However, since this area is entirely over water, the contamination would be quickly diluted by tidal flow and turbulence.

F.1.5 Analysis of Uncertainties

The analyses of the impacts of normal operations and hypothetical accidents associated with management of naval spent nuclear fuel presented in this Environmental Impact Statement (EIS) are based on conservative calculations. This is necessary because virtually all of the events analyzed have never occurred and most of the impacts of routine operations are so small that they cannot be measured. The use of calculations introduces the possibility that the actual impacts may differ from those calculated due to various kinds of uncertainties, such as differences between actual behavior and the theoretical models or equations and the variability of the values of factors used in the calculations. In order to portray the effects of such variability and uncertainty, the analyses performed for this appendix have been divided into four components: the probability that an event, such as an accident, could occur; the amount of radioactive material or radiation that might be released by the event; the calculation of the potential for exposure to human beings from the release; and the conversion of the radiation exposure to detrimental health effects. Each of these components is discussed separately in the following sections for both routine operations and accidents.

Each of these components has been analyzed for both routine operations and accidents. The discussion in the following sections focuses on accident analyses, but it should be understood that the analysis of uncertainties for routine operations is the same, with a few exceptions. First, routine operations are certain to occur, so the "probability" of such events is effectively 1.0. Second, the source terms used for the analyses of routine operations are based on monitoring of current operations at Naval Nuclear Propulsion Program facilities such as the Expended Core Facility at INEL. Consequently, the estimates of the amount of radiation or radioactivity involved are expected to be close to those which might actually occur under the alternatives evaluated in this EIS. It is possible that there would be some variations among facilities and that future efforts to keep exposures to workers as low as reasonably achievable might reduce the source terms further, but the values used in the analyses in this EIS are expected to be little different from those actually encountered. The effects of routine operations and accidents have been calculated using similar analytical methods and models for determination of radionuclide movement in the environment, pathways to humans, and conversion of exposure to health effects. Therefore, the discussion of uncertainties in Sections F.1.5.3 and F.1.5.4 applies to the results of analyses of routine operations, as well as to postulated accidents.

F.1.5.1 Probabilities of Events. The probability that an accident might occur has been determined for a number of events which might reasonably be postulated. These probabilities are used in this appendix to calculate the risk, defined as the product of the probability times the consequences, for each postulated accident.

The best methods available have been used to estimate the probabilities for the events selected for analysis. For example, a methodology developed by Sandia Laboratories (Sandia 1983) was used to compute the probability that an aircraft might crash into naval spent nuclear fuel facilities. This method uses actual aircraft crash statistics obtained from the Federal Aviation Administration and was developed by Sandia to reproduce the observed frequencies as closely as possible. Probabilities for seismic events were derived from published studies of the frequencies of seismic activity and represent the best available estimates, but these probabilities are subject to some uncertainty due to the relatively few events which have occurred at the sites evaluated under the alternatives in this EIS.

The probabilities of a range of accidents which might be caused by human error have also been included. Such events include accidental criticality caused by handling errors, dropping of fuel modules, improper operation of cranes, and incorrectly performing machining procedures. For human error, a probability of one error in one thousand operations (a frequency of 10-3 events per year) is used for operations performed by a single trained operator following a written procedure. If the procedure requires verification of the action by a second trained operator, this frequency is lowered to 10-4. These probabilities are derived from the methodology used by the Nuclear Regulatory Commission for assessment of human reliability (Swain 1983).

In many instances, the probabilities assigned to the events reflect the likelihood that a particular event, such as an earthquake or an aircraft crash, might occur. However, for the purpose of the analyses, the resulting accident was assumed to have quite severe consequences. The probability of such severe consequences is smaller than the probability that the initiating event might occur, with consequences as severe as used in the analyses possibly occurring only one time in 10 or 100 occurrences of the initiating event. The probabilities for most of the analyses in this appendix used only the probability of the initiating event and did not include the further reduction in the probability of the postulated severe consequences resulting from the severity used. This was done, in part, because the severe consequences assumed, and in some cases the initiating events themselves, occur very infrequently, or have never occurred, so little data on their frequency is available.

For example, one accident analyzed is the impact on a spent fuel container of a missile produced by a tornado or other high winds. The sequence of events analyzed included breaching the container seal in order to release radioactive material. In reality, the missile would have to be large enough and traveling at high enough speed to cause the postulated damage. Similarly, it would have to contact the container at the correct location and at the correct angle in order to damage the seal. The probability assigned to this accident is 10-5 per year, the probability that a wind-driven missile might strike a container, and does not include any factor to account for other elements in the sequence required to actually damage the seal. Therefore, the probability of the consequences calculated for this accident would be much smaller than the probability of 10-5 per year used in the analysis.

A second example is provided by the analysis of aircraft impact on shipping containers used for storage of naval spent nuclear fuel. In this accident analysis, the impact was assumed to cause a shipping container to be penetrated if the container were contacted by the aircraft. However, naval spent nuclear fuel shipping containers are of very rugged design, and structural analysis of the container showed that a naval shipping container is very unlikely to be penetrated by an aircraft crash, even by the hardest parts of the airplane. Consequently, the probability that the naval spent nuclear fuel could be damaged and that fission products might be released is much, much less than the crash probability alone, which is the probability assigned to these consequences in this appendix.

A third example is seen in the ship fire accident. In this analysis, it is assumed that if a ship carrying naval spent nuclear fuel shipping containers were involved in a very severe collision and a fire occurred, the fire would include the cargo hold where the naval spent nuclear fuel containers are carried, the fire would not be extinguished by the redundant systems provided, and it would burn long enough at sufficient intensity to damage the shipping container and the spent nuclear fuel inside and cause release of radioactive materials from the containment provided. Given that a severe collision occurred, the probability that all of the necessary conditions would occur and a fire of the required intensity and duration would occur in the cargo hold is clearly far less than the probability of the collision.

As can be see from these examples, the actual probability of the consequences resulting from the analyses are smaller than the values presented in this appendix, at least in part because these probabilities do not include an additional factor to reflect the accident severity used in the analyses. As a result, the risks stated in this appendix for most accidents are believed to be at least 10 to 100 times larger than what would actually occur. However, the same probabilities have been used in the evaluation of all of the alternatives considered and all of the risks are small, so the approach used is adequate for the purposes of this EIS.

F.1.5.2 Release of Radioactive Material or Radiation (Source Term). Since the source terms used in the accident analyses are typically for accidents which have never occurred, there is greater room for uncertainty. All of the accidents analyzed in this EIS are intended to be accidents which produce consequences which are unlikely to be exceeded by any reasonably foreseeable accident. As a result, the accidents themselves and the sequences of events during the accidents have been chosen to maximize the source term. For example, systems such as high efficiency particulate filters have been considered to be inoperative in all cases where the accident might have an opportunity to disable them.

The source terms for the hypothetical accident analyses are dependent upon a number of factors. For there to be an accidental release of radioactivity to the environment, there must be damage to the storage facility or containment structure. Furthermore, naval spent nuclear fuel must be damaged as well in order for there to be any release of fission products since all fission products are fully contained within naval nuclear fuel. The amount of damage to the external containment or the fuel is dependent upon the severity and the nature of the accident. In the accidents analyzed, there are assumptions concerning the containment or the extent of damage to the fuel units which were made to provide a conservative, bounding evaluation whose results would not be exceeded by reasonably postulated accidents of a similar type.

One example of this is the evaluation of the dry storage container impacted by a wind-driven missile. Damage to the container by the missile is not expected to occur, but for the analysis in this EIS, the seal is assumed to be damaged by the missile impact and corrosion products within the container are assumed to be released through the damaged seal. The uncertainty on the resultant release is one-sided since the probability of a release larger than in the calculation (resulting in a higher calculated dose) is essentially zero while the possibility of a release of less radioactive material is large (for example, no release if the container seal is not broken). The range of variation, or the uncertainty interval, in the source term for this accident is between +0% and -100%.

Another example is the plane crash into a dry processing facility for naval spent nuclear fuel. The dry processing facility includes a thick concrete shielded cell in which a few naval spent nuclear fuel units are processed at a time. The massive concrete shield is provided to protect operating personnel from radiation but it has the secondary benefit of protecting the fuel units being processed from missiles caused by natural or man-made phenomena. In the unlikely event that an airplane crashed into the facility, it is expected that no damage to the spent fuel would result. Even so, for evaluation of this accident in this EIS, it is assumed that 1% of the fuel in the dry cell could be damaged and that sufficient jet fuel could enter the dry cell to cause a fire which could cause the release of fission products from the damaged fuel and destroy the filtration system. Again, the uncertainty range is one-sided since no damage to fuel is expected, causing the variability or uncertainty to range from +0% to -100%.

All of the source terms used for the evaluation of the accidents were developed in a similar fashion. Thus, the expected outcome for all of the accidents is that a lower release to the environment is expected than is used in the analysis, representing a range of variation of +0% to -100%.

F.1.5.3 Exposure to Humans. Exposure to the individuals and the general population is evaluated by

integrated computer programs. The methods used model the movement of airborne, ground, and water contamination resulting from the postulated release using five types of pathways to the population. These pathways include exposure directly to the radiation from the material in the plume, direct exposure to radiation from contaminated soil or water, inhalation of air containing gases or particles, and ingestion of contaminated water or food. The analyses in this appendix used parameter values which were the best available estimates or, when best estimate values were not available, are conservative.

The Gaussian plume model used in these analyses to represent airborne movement of radioactive material is the standard used in virtually all evaluations of environmental effects. Comparison of distributions calculated using the Gaussian plume model with test data has shown that the results may differ by as much as a factor of 5 in some circumstances. In order to ensure that exposures would be as high as could occur under any set of conditions, in most of the analyses a ground level release was used and no reduction in the airborne concentrations was included for either turbulence caused by buildings or the effect of wind meander which occurs naturally at the low wind speeds accompanying the worst case meteorological conditions.

One intentional choice of parameters to ensure that the results would be conservative is the use of the worst case meteorological conditions in the tabulations of the risks and consequences for all alternatives provided in Chapters 3 and 5. The results for both the most likely meteorological conditions and for the worst case are provided in detailed tables in this attachment and show that the worst case meteorological conditions produce exposure estimates which are 2 to 10 times higher than those for the most likely conditions (depending upon local meteorological conditions). Overall, the net effect is that the Gaussian plume model might introduce an uncertainty of a factor of 5 or less in either direction, but the use of the worst case meteorological conditions would essentially offset any underestimation of effects.

The direct radiation from the cloud is calculated using a conservative representation of the plume as a finite cloud, and, as a result, little uncertainty is introduced in this part of the analysis. Direct radiation from contamination which results from particles from the plume deposited on the ground surface depends upon the deposition parameters which are input as best-estimate values. Faster deposition would result in more material on the ground and increased exposure to those closer to the accident location but less material on the ground and decreased exposure for those farther from the accident site. Any effects of uncertainty in this parameter would depend upon the population distribution around the postulated accident scene.

The possible exposure to direct radiation from material in surface water and associated sediments as a result of accidental release directly to the water or fallout from an airborne release was estimated for people involved in activities such as professional fishing, maritime operations, swimming, and boating. The calculations took no credit for dilution by river currents or tidal movement and the concentrations in the air were not reduced by the amount of material deposited in the water. Due to the conservative concentrations used in the calculations and an assumption that every member of the population in the area would be exposed to direct radiation from surface waters, exposure from this pathway is very likely overestimated.

The inhalation pathway evaluation is based on average breathing rates and uptake consistent with the recommendations by the ICRP (ICRP 1977 and ICRP 1979). Obviously, higher values for these parameters would increase the estimated exposures and lower values would decrease the estimates. There appears to be little controversy concerning these parameters and the same parameters are used for evaluation of all of the alternatives in this appendix.

The ingestion pathway includes meat, seafood, dairy and crop products, and drinking water. Best-estimate parameters are used to evaluate the contamination levels in food and water when ready for consumption. Consumption rates for individuals are based on observed eating habits. The analysis also includes the assumption that a conservative 10% of the entire diet of the affected population consists of contaminated products. The uncertainties associated with these pathways can obviously affect the estimated impacts, but the range of variation is not large and the same values for a given site were used for evaluation of all alternatives.

The drinking water contribution to the ingestion pathway was calculated by assuming that a portion of the radioactive material would become dissolved in the drinking water supply. At sites where fresh surface water provides drinking water, any contamination of the water was assumed to occur promptly and no decreases due to radioactive decay were used. At sites where aquifers are a source of drinking water, consumption of water from the aquifer was delayed for the time required for the contamination to reach the aquifer and then to reach the nearest drinking water source. As an example, for a postulated leak from the Expended Core Facility, it was assumed that 20 years would pass before water carrying the radioactive material would reach a well drawing from the aquifer and that 1 percent of material released would enter the aquifer each year. Maximum exposed individuals were conservatively assumed to drink only water from the contaminated source and to drink 2 liters of water per day. For the population in general, a conservative fraction of the population was assumed to drink 1 liter of water per day from affected sources. The concentrations in these calculations are considered to be higher than expected because no reduction of the concentration by dilution was included and the fraction of the population exposed to the affected drinking water is conservatively high.

At sites where irrigation is used, contamination of food crops, livestock, and local game was analyzed. The same concentration of radioactive material as in drinking water was used in the irrigation water. Affected crops, livestock, and game were assumed to receive all water from the contaminated water source and applicable biological accumulation factors were used. Human consumption rates for the crops, livestock, and game were used to calculate the exposure from this source. The uncertainty from this source is associated with the concentration of contaminants in the irrigation water, the amount of such foods consumed, and the fraction of the population which ingests the affected food.

The population used to determine the effects of postulated accidents in this appendix is the entire population within the 22.5-degree sector at each distance within 50 miles downwind of the accident. The spread of the plume for the worst case meteorology does not cover the entire sector. The result is that there is a conservatism of more than a factor of 2 in the application of the calculations to the evaluation of the dose to the population. The population data used were obtained from the 1990 U. S. census, so population growth or decreases in a region could introduce small changes, but the same population distributions were used for a specific site for evaluation of all alternatives.

Considering all of the factors which might have an appreciable effect on the results of the analyses, any tendency of the Gaussian plume model to underestimate concentrations would be offset by the use of other parameters which are known to be conservative. Examples of such conservative factors include the general use of the meteorological conditions which would produce the most severe effects and the use of the entire population of a 22.5-degree sector. Consequently, this portion of the analyses would appear to contribute little in the way of uncertainty which could cause the results to be greater than presented in this appendix.

F.1.5.4 Conversion of Exposure to Health Effects. The conversion of amounts of radiation or

radioactive material transmitted to an individual or to population groups requires the calculation of the exposure or dose received by humans caused by inhaling or ingesting radioactive material or by being in a radiation field. Such calculations are based on a number of factors, including the nature and rate of human metabolic processes, such as respiration or excretion, the type of radiation involved, the sensitivity of various organs, and the age of the individuals involved. The rates of human metabolic processes are well characterized at this time and the energies, half-lives, and similar properties of radioactive material or radiation have been measured extensively and are not subject to great debate. Consequently, these factors introduce little uncertainty into the calculations in this EIS.

However, the number of detrimental health effects which might result from exposure of a large group of people to low levels of radiation has been the subject of debate for many years. The National Academy of Sciences has conducted several investigations of this matter and its full commentary on page 181 of its latest study of the health effects of exposure to low levels of radiation, frequently identified as BEIR V (NAS 1990), states:

> Finally, it must be recognized that derivation of risk estimates for low doses and dose rates through the use of any type of risk model involves assumptions that remain to be validated. At low doses, a model dependent interpolation is involved between the spontaneous incidence and the incidence at the lowest doses for which data are available. Since the committee's preferred risk models are a linear function of dose, little uncertainty should be introduced on this account, but departure from linearity cannot be excluded at low doses below the range of observation. Such departures could be in the direction of either an increased or decreased risk. Moreover, epidemiologic data cannot rigorously exclude the existence of a threshold in the millisievert dose range. Thus, the possibility that there may be no risks from exposures comparable to external natural background radiation cannot be ruled out. At such low dose rates, it must be acknowledged that the lower limit of the range of uncertainty in the risk estimates extends to zero.

The National Academy of Sciences considers that the uncertainty in the lifetime total excess cancer mortality risk estimates calculated using the linear extrapolation, no threshold models it has designated as preferred, which is consistent with the model used in this EIS, is approximately a factor of 2 in either direction (an interval of 0.5 to 2 times the calculated estimates).

The calculations of health effects performed in this Environmental Impact Statement use the relation recommended by the International Council on Radiation Protection because it is well-documented and kept up to date by the Council. It is also consistent with the preferred model identified by the National Academy of Sciences in the BEIR V report and is widely accepted by the scientific community as representing a method which produces estimates of health effects which will not be exceeded. However, there are some who believe that exposure to low levels of radiation can produce more health effects than would be estimated using the International Council on Radiation Protection relation. On the other hand, a growing number of researchers believe that the International Council on Radiation Protection relation overestimates the number of detrimental health effects produced by low levels of radiation and, in fact, the possibility of no effect cannot be excluded (CIRRPC 1992).

Clearly, using a relation developed by one or the other of these groups would produce a larger or smaller estimate of the number of health effects than the values presented in this EIS, but a factor of 2 change in the small risks calculated for all of the alternatives would still leave them as small risks. All of the results of analyses of normal operations and hypothetical accidents in Appendix D include the calculated exposure in addition to the number of health effects in order to permit independent calculations using any relation between radiation exposure and health effects judged appropriate.

F.1.5.5 Summary of Uncertainties. As discussed in the preceding portions of this section, the calculations in this EIS have generally been performed in such a way that the estimates of risk provided are unlikely to be exceeded during either normal operations or in the event of an accident. For routine operations, the results of monitoring of actual operations provide clearly realistic source terms, which, when combined with conservative estimates of the effects of radiation, produce estimates of risk which are very unlikely to be exceeded. The effects for all alternatives have been calculated using the same source terms and other factors, so this EIS provides an appropriate means of comparing potential impacts on human health and the environment.

The analyses of hypothetical accidents provide more opportunities for uncertainty, primarily because the calculations must be based on sequences of events and models of effects which have not occurred. In this appendix, the goal in selecting the hypothetical accidents analyzed has been to evaluate events which would produce effects which would be as severe or more severe than any other accidents which might reasonably be postulated. The models have attempted to provide estimates of the probabilities, source terms, pathways for dispersion and exposure, and the effects on human health and the environment which are as realistic as possible. However, in many cases, the very low probability of the accidents postulated has required the use of models or values for input which produce estimates of consequences and risks which are higher than would actually occur because of the desire to provide results which will not be exceeded. In summary, it is judged that the risks presented in this appendix are believed to be at least 10 to 100 times larger than what would actually occur.

The use of conservative analyses is not an important problem or disadvantage in this EIS since all of the alternatives have been evaluated using the same methods and data, allowing a fair comparison of all of the alternatives on the same basis. Furthermore, even using these conservative analytical methods, the risks for all of the alternatives are small, which greatly reduces the significance of any uncertainty analysis parameters.

F.2 TOXIC CHEMICAL ISSUES AT NAVAL SPENT NUCLEAR FUEL EXAMINATION AND STORAGE SITES

The INEL-ECF is a large laboratory facility used to receive, examine, and ship naval nuclear fuel and irradiated test specimen assemblies. In order to accomplish these tasks, some chemicals classified as toxic are involved in a variety of operations and thus a potential exists for releases of toxic chemicals due to human error and failure or malfunctioning of equipment.

This section provides the results of an evaluation of both normal operations and accidents that could result in toxic chemical releases. This section describes how facilities and operations were selected for analysis, discusses the computer codes used in the analysis, presents the weather conditions and atmospheric dispersion, defines the hypothetical accidents which would produce the most severe consequences, and estimates the potential health effects. Each alternate location's specific population and meteorology were used to produce estimated consequences for each operation and accident.

F.2.1 Toxic Chemical Inventory

Some chemicals classified as toxic are routinely used in a variety of operations at the INEL-ECF. Table F.2-1 provides the INEL-ECF Chemical Inventory. This inventory was developed from the Naval Reactors Facility Superfund Amendments and Reauthorization Act (SARA) Section 312 chemical inventory (INEL 1993). Those chemicals specifically stored and used at INEL-ECF as well as those used for facility support (e.g., fuel oil, diesel fuel, sulfuric acid, and sodium hydroxide) were included. Chemicals at INEL-ECF that were (a) in excess of 500 pounds, or (b) in excess of reportable quantities (usually 1 pound) on the EPA Title III List of Lists (EPA 1992a) were evaluated. The chemicals in the EPA Title III List of Lists are the hazardous chemicals defined in:

- SARA Section 302 Extremely Hazardous Substances (CFR 1992a)
- CERCLA Hazardous Substances (CFR 1992b)
- SARA Section 313 Toxic Chemicals (CFR 1992c)
- RCRA Hazardous Wastes (CFR 1992d)
- EPA list of 100 extremely hazardous chemicals (FR 1993).

Table F.2-1. INEL-ECF chemical inventory.

CAS No.	Chemical Name	Weight Total (pounds)	Weight Unit[1] (pounds)
Chemicals Used for Water Pool Operations			
60-00-4	Ethylenediaminetetraacetic Acid (EDTA) (reagent for water analyses)	46.3	1.1
75-71-8	Dichlorodifluoromethane (CFC-12) (refrigerant in coolers for pool water)	30.0	30.0
Chemicals Used for Examination Operations			
60-29-7	Ethyl Ether	5.7	5.7
67-63-0	Isopropyl Alcohol	100.6	6.6
123-31-9	Hydroquinone (photographic film developer)	65.5	3.3
144-55-8	Sodium Bicarbonate	198.0	99.0
302-01-2	Hydrazine	3.7	1.8
7664-41-7	Ammonia[2]	2.8	0.28
7727-37-9	Diatomic Nitrogen	643	125
Chemicals Used for Facility Support			
107-21-1	Ethylene Glycol (anti-freeze and paint additive)	516.1	514.0
115-07-1	Propylene (Propene)	0.01	0.005
1310-73-2	Sodium Hydroxide (boiler water pH control)	43260	43260
7664-93-9	Sulfuric Acid (boiler and cooling tower water pH control)	96427	96427
68476-33-5	Fuel Oil #5	776210	204270
68476-34-6	Diesel Fuel #2	14316	10735
72623-83-7	Hydrotreated Lubricating Oil	882.6	413
Chemical Used for Nuclear Poison			
1332-77-0	Potassium Tetraborate	17000	10

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[1] The quantities in this column represent the amount of chemical stored in the largest single container as identified in the INEL-ECF chemical inventory.

[2] The ammonia is present as ammonium hydroxide.

In order to evaluate the alternate locations, the same inventory of chemicals at the INEL-ECF was used at the DOE sites; namely, the Savannah River Site, the Hanford Site, the Nevada Test Site, and the Oak Ridge Reservation. In addition, the Barnwell Nuclear Fuel Plant (hereafter referred to as the Barnwell Plant), which is adjacent to the Savannah River Site, was evaluated along with the DOE sites. Since the shipyards would not be involved with examination operations (except for Puget Sound), of the chemicals listed, only diesel fuel would be available in a substantial quantity, in the form of fuel stored at the shipyards. Although several of the chemicals listed in Table F.2-1 are water treatment chemicals associated with water pool operations and small water pools may be needed at the shipyards for fuel storage and inspection, the shipyard would already have on-hand similar water treatment chemicals for other operations at the shipyard. Therefore, an increase in the quantities or types of chemicals at the shipyards was considered to be very small and thus did not require evaluation. In addition, even though the Kenneth A. Kesselring Site is not a shipyard, this facility would also not be involved with examination operations. Therefore, this facility was evaluated in the same manner as the shipyards.

F.2.2 Computer Modeling to Estimate Toxic Chemical Exposures

Factors such as locations of affected persons, terrain, meteorological conditions, release conditions, and characteristics of the chemical inventory are required as input parameters for calculations to determine human exposure from airborne releases of toxic chemicals. This section describes the computer models used to perform exposure estimates. Specific input parameters used in the analyses are summarized in the appropriate subsection for normal operations and accident conditions. The EPIcode was used to evaluate toxic chemical releases resulting from accidents, and the ISC2 code was used to evaluate releases from normal operations.

F.2.2.1 EPIcode (tm). The Emergency Prediction Information Computer Code (EPIcode-) is the

computer code chosen for estimating airborne concentrations resulting from most releases of toxic chemicals (Homann 1988). Like RSAC, EPIcode uses the well-established Gaussian Plume Model to calculate the airborne toxic chemical concentrations usually at the same downwind locations as RSAC.

The EPIcode library contains information on over 600 toxic substances listed by the American Conference of Governmental Industrial Hygienists in the EPIcode Manual. EPIcode also allows user description of substances not included in the library. A step-by-step flow chart of the main EPIcode features (up to the output options) is shown in Figure F.2-1.

Figure F.2-1. Flow sheet for EPIcode (Homann 1988).

As shown in Figure F.2-1, the continuous release models require specification of the source term as an ambient concentration and a release rate. For releases over a specific time interval (i.e., term releases), the user specifies the release duration and the total quantity of material released.

Area continuous and area term releases are useful in calculating the effects of a release from pools of spilled volatile liquids. The user must enter the radius of the circle encompassing the spill area. Also entered is the temperature of the pool and ambient temperature to establish release rate from a liquid spill. An upwind virtual point source, which results in an initial lateral diffusion equal to the effective radius of the area source, is used to model an area release.

By specifying a release quantity, release duration, and release area, the user effectively proposes a release rate per unit spill area. The release quantity is defined as a source term (Q) or fraction of the material at risk. The concepts and defined terms are the same as for radiological calculations. EPIcode confirms that the volatility of the spilled substance can support such a release rate. If the proposed release rate exceeds the saturation conditions at the release temperature, EPIcode calculates a lower release rate and a corresponding longer release time.

In calculating effective release height, the actual plume height may not be the physical release height, e.g., the stack height. Plume rise can occur because of the velocity of a stack emission and the temperature differential between the stack effluent and the surrounding air. EPIcode calculates both the momentum plume rise and the buoyant plume rise and chooses the greater of the two results.

Since this effective increase in release height leads to lower concentrations at the ground level, the physical release heights were used to calculate the concentrations that the general public may be exposed to during accidental releases of toxic substances. This approach will always yield conservative estimates.

In this application, the standard terrain calculation of EPIcode is always used. Downwind concentrations were calculated using both 95% and 50% meteorological conditions (Section F.1.3.5). The elevation of the affected person is always ground level (0 meters) and, as in RSAC-5, the mixing layer height is always 400 meters (1320 feet). The deposition velocities used (Section F.2.4.2.1.3) are somewhat different than those of RSAC-5, but they are still conservatively low.

As described in its user manual (Homann 1988), EPIcode also includes the following steps:

- Treating a release as instantaneous vs. continuous depending upon the plume length at the specific downwind location being considered
- Correcting the concentration for sampling time
- Adjusting the wind speed for release height
- Depleting the plume as a function of downwind distance
- Adjusting the standard deviations of the crosswind and vertical concentrations for brief releases.

As output, EPIcode can generate data plots of mean toxic chemical concentration (during a specified averaging time) as a function of downwind distance. From these graphs and numerical output, the concentrations for the worker at 100 meters (330 feet) (the shortest distance for which EPIcode calculates), for the nearest public access (NPA), for the maximum off-site individual (MOI), and for nearby communities are determined and evaluated for health effects.

EPIcode was selected as the computer code for release analysis of chemicals amenable to Gaussian modeling after comparison with a number of codes, primarily CHARM and ARCHIE. It was judged more applicable for this application than either the CHARM code or the comparable ARCHIE code.

F.2.2.2 ISC2 Code. The Industrial Source Complex (ISC2) model is a widely used, publicly

available, and accepted EPA regulatory model which employs straight line (i.e., uniform wind field) Gaussian diffusion to estimate pollutant dispersion (EPA 1992b). ICS2 is an appropriate model for industrial complexes in rural or urban areas with transport distances less than 50 kilometers (30 miles). This model employs a standard meteorological data set requiring single point hourly wind speed, wind direction, ambient air temperature, atmospheric stability, and vertical mixing height values. Also, the ISC2 model is able to account for variations in pollutant concentrations due to the influence of nearby structures.

In addition to the ISC2 model, the MESOPUFF II model was also evaluated. MESOPUFF II is a regional (mesoscale) scale model that takes into account a varying wind field. Past trajectory analyses at the INEL have demonstrated that plumes may undergo many changes in direction due to the varying winds common to the INEL vicinity. The number of changes is partially dependent on release time and transport duration. The plume transport and estimation of pollutant concentration beyond 12 miles (20 kilometers) is best modeled using spatially varying wind data. Although not used as a basis for determining or enforcing compliance with regulations, it is used on a case-by-case basis. The model is also readily available to the public.

Upon review of the ISC2 and MESOPUFF II models, the decision was made to utilize ISC2 for the dispersion analysis of pollutants emitted from stationary sources. ISC2 is able to reasonably and accurately predict downwind pollutant concentrations within 30 miles (50 kilometers) by taking into account multiple point and area emission sources, evaluating hourly meteorological data, and determining the effects of nearby structures.

F.2.3 Health Effects

Toxic constituents dispersed during an accident could induce adverse health effects among exposed individuals. This possible impact is assessed by comparing the airborne concentrations of each substance at specified downwind locations to standard accident exposure guidelines for chemical toxicity.

Where available, Emergency Response Planning Guideline (ERPG) values are used for this comparison. ERPG values are estimates of airborne concentration thresholds above which one can reasonably anticipate observing adverse effects (Rusch 1993). ERPG values are specific for each substance, and are derived for each of three general severity levels:

- Exposure to concentrations greater than ERPG-1 values results in an unacceptable likelihood that one would experience mild transient adverse health effects, or perception of a clearly defined objectionable odor.
- Exposure to concentrations greater than ERPG-2 values results in an unacceptable likelihood that one would experience or develop irreversible or other serious health effects, or symptoms that could impair one's ability to take protective action.
- Exposure to concentrations greater than ERPG-3 values results in an unacceptable likelihood that one would experience or develop life-threatening health effects.

Where ERPG values have not been derived for a toxic substance, other chemical toxicity values are substituted, as follows:

- For ERPG-1, Threshold Limit Value, Time-Weighted Average (TLV-TWA) values (ACGIH 1993) are substituted: The TWA is the time-weighted average concentration for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.
- For ERPG-2, Level of Concern values (equal to 0.1 of Immediately Dangerous to Life or Health) are substituted: Level of Concern is defined as the concentration of a hazardous substance in air, above which there may be serious irreversible health effects or death as a result of a single exposure for a relatively short period of time (EPA 1987).
- For ERPG-3, Immediately Dangerous to Life or Health (IDLH) values are substituted: IDLH is defined as the maximum concentration from which a person could escape within 30 minutes without a respirator and without experiencing any effects which would impair the ability to escape or irreversible side effects (NIOSH 1990).

Possible health effects associated with exceeding an ERPG-2 or -3 value are specific for each substance of concern, and must be characterized in that context. When concentrations are found to exceed an ERPG or substitute value, the specific toxicological effects for the chemicals of concern are considered in describing possible health effects associated with exceeding a threshold value.

ERPG values are based upon a 1-hour exposure of a member of the general population. In this EIS, exposures resulting from the release of toxic chemicals during an accident condition were postulated to occur over a period of 1 hour or less to allow for a direct comparison to the ERPG values. This approach provides an additional element of conservatism in the evaluation of accidents with releases that last much less than 1 hour.

In addition to comparing the airborne concentrations of each substance to standard accident exposure guidelines, each substance was evaluated to determine if it has the potential for future carcinogenic health impacts. If a particular substance has this potential, the Integrated Risk Information System (IRIS) (TOXnet 1993) was reviewed and if sufficient toxicological information was available, a future potential likelihood of developing cancer was determined. If sufficient information from IRIS was not available, alternative evaluation methods, including comparison to ambient air quality criteria, were substituted.

The impact of normal operations was also evaluated. This impact was assessed by comparing the airborne concentrations of each substance at specified downwind locations to the National Ambient Air Quality Standards (NAAQS) assigned for each substance. NAAQS consist of national primary and secondary ambient air quality standards (CFR 1991). National primary ambient air quality standards define levels of air quality which the EPA judges are necessary, with an adequate margin of safety, to protect the public health. National secondary ambient air quality standards define levels of air quality which the EPA judges are necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant. As a result, the immediate as well as cumulative impact of normal operations was evaluated by comparing the airborne concentrations of each substance to the NAAQS.

F.2.4 Analysis Description and Results

The analysis results for both normal operations and accident conditions are reported for each location analyzed. Detailed estimated concentrations and ERPG levels, expressed in milligrams per cubic meter (mg/m3), are reported in tabular form for a worker, maximally exposed collocated worker (MCW), maximally exposed off-site individual (MOI), and maximally exposed individual at the nearest public access (NPA). A complete description of these individuals is provided in Section

F.1.3.2.

F.2.4.1 Normal Operations.

F.2.4.1.1 Source of Emissions. Emissions resulting from normal operations involving

toxic chemicals listed in Table F.2-1 were evaluated. It was determined that the burning of Number 5 fuel oil in the facility's boilers and the burning of Number 2 diesel fuel in the facility's emergency diesel generators represented the largest sources of emissions under normal operations and thus provide the conditions producing the most severe consequences for evaluation. These normal operations result in the release of oxides of nitrogen (90% nitric oxide and 10% nitrogen dioxide), sulfur dioxide, particulates (PM-10), lead, and volatile organic compounds (VOCs). The airborne release of these chemicals was evaluated for effects on the on-site workers, MCW, NPA, and MOI.

The emissions that occur due to normal operations at the INEL-ECF were evaluated using the ISC2 code. These releases were also used at the alternate locations (Hanford, Savannah River, Nevada Test Site, Barnwell Plant, and Oak Ridge) for evaluation purposes. Heating boilers and emergency diesel generators already exist at the alternate shipyard locations and thus selection of these alternate locations would not result in a measurable increase in emissions. Therefore, routine releases from shipyard locations were not considered.

F.2.4.1.2 Conditions and Key Parameters.

- Number 5 fuel oil was burned in facility boilers for space heating.
- Number 2 diesel fuel was burned in facility emergency diesel generators.
- Source term was based on the INEL report on routine yearly releases (NRF 1993) which included:
  - 1.02 tons per year of carbon monoxide released
  - 9.04 tons per year of oxides of nitrogen released
  - 33.7 tons per year of sulfur dioxide
  - 1.54 tons per year of particulates
  - 5.86 x 10-4 tons per year of lead
  - 0.18 tons per year of volatile organic compounds.
- Forty percent of the total boiler and emergency diesel generator use for the Naval Reactors Facility was attributed to the INEL-ECF.
- Three point sources (one representing boilers and two representing emergency diesel generators) were used.
- Stack diameters of 1.07 meters (3.5 feet) for boilers and 0.305 meter (1 foot) for emergency diesel generators were used.
- Stack gas exit velocities of 21.8 meters per second (72 feet per second) for boilers and 44.2 meters per second (145 feet per second) for emergency diesel generators were used.
- Stack gas exit temperatures of 505yK for boilers and 794yK for emergency diesel generators were used.
- Worker concentrations were based on 16 sector polar grids. Other affected locations were defined as discrete points.
- DOE site meteorological data were used for evaluations at the Naval Reactors Facility, Hanford, Nevada Test Site, and Oak Ridge. Meteorological data from the closest National Weather Service Station were used for evaluations at Savannah River and the Barnwell Plant.

F.2.4.1.3 Results. The airborne concentrations, averaged over the duration of each

exposure, were calculated by ISC2 for the worker, MCW, NPA, and MOI using normal meteorology. Tables F.2.4.1-1 through -6 list the downwind concentrations at various locations. The airborne concentrations were compared to respective NAAQS values where available. The NAAQS are as follows:

Carbon monoxide. The national primary ambient air quality standards for carbon monoxide are 10 mg/m3 for an 8-hour average concentration not to be exceeded more than once per year, and 40 mg/m3 for a 1-hour average concentration not to be exceeded more than once per year.

Sulfur oxides. The national primary ambient air quality standards for sulfur oxides that are measured as sulfur dioxide are 0.08 mg/m3 as an annual arithmetic mean and 0.365 mg/m3 as a maximum 24-hour concentration not to be exceeded more than once per year. The national secondary ambient air quality standards are 1.3 mg/m3 as a maximum 3-hour concentration not to be exceeded more than once per year.

Nitrogen dioxide. The national primary and secondary ambient air quality standard for nitrogen dioxide is 0.1 mg/m3 as an annual arithmetic mean.

Lead. The national primary and secondary ambient air quality standard for lead and its compounds that are measured as elemental lead is 1.5 x 10-3 mg/m3 as a maximum arithmetic mean averaged over a calendar quarter.

Particulate matter. The national primary and secondary ambient air quality standard for particulate matter is 0.05 mg/m3 as an annual arithmetic mean and 0.15 mg/m3 as a maximum 24-hour concentration.

A comparison of the downwind concentrations provided in Tables F.2.4.1-1 through -6 with the NAAQS identified above indicates that no NAAQS is exceeded for normal operations.

Table F.2.4.1-1. Summary of chemical concentrations for normal operations at the INEL Expended Core Facility.

	CHEMICAL CONCENTRATIONS mg/m3						
	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead	VOC	PM-10
Worker	4.6 x 10-5	5.5 x 10-4	1.9 x 10-4	2.1 x 10-5	9.0 x 10-9	1.9 x 10-5	2.7 x 10-5
MCW	3.7 x 10-6	9.5 x 10-5	2.6 x 10-5	2.9 x 10-6	2.0 x 10-9	8.5 x 10-7	4.6 x 10-6
MOI	7.7 x 10-7	2.3 x 10-5	5.8 x 10-6	6.4 x 10-7	<1.0 x 10-9	1.6 x 10-7	1.1 x 10-6
NPA	7.7 x 10-7	2.3 x 10-5	5.8 x 10-6	6.4 x 10-7	<1.0 x 10-9	1.6 x 10-7	1.1 x 10-6

Table F.2.4.1-2. Summary of chemical concentrations for normal operations at Hanford.

	CHEMICAL CONCENTRATIONS mg/m3						
	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead	VOC	PM-10
Worker	2.9 x 10-5	1.5 x 10-4	1.3 x 10-4	1.0 x 10-5	3.0 x 10-9	1.1 x 10-5	1.4 x 10-5
MCW	1.6 x 10-5	2.1 x 10-4	9.6 x 10-5	1.1 x 10-5	5.0 x 10-9	4.7 x 10-6	1.5 x 10-5
MOI (New ECF)*	1.0 x 10-6	3.2 x 10-5	8.0 x 10-6	8.9 x 10-7	1.0 x 10-9	2.0 x 10-7	1.5 x 10-6
MOI (FMEF)**	1.4 x 10-6	4.0 x 10-5	1.1 x 10-5	1.2 x 10-6	1.0 x 10-9	3.0 x 10-7	1.9 x 10-6
NPA	1.3 x 10-6	4.1 x 10-5	1.0 x 10-5	1.1 x 10-6	1.0 x 10-9	2.6 x 10-7	1.9 x 10-6

*MOI (New ECF) applies if spent fuel facility is constructed at the 200 Area on the Hanford Site.

**MOI (FMEF) applies if spent fuel facility is constructed at the Fuels and Materials Examination Facility.

Table F.2.4.1-3. Summary of chemical concentrations for normal operations at Savannah River.

	CHEMICAL CONCENTRATIONS mg/m3						
	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead	VOC	PM-10
Worker	1.5 x 10-5	6.4 x 10-5	6.4 x 10-5	7.1 x 10-6	1.0 x 10-9	6.2 x 10-6	5.9 x 10-6
MCW	9.4 x 10-6	1.6 x 10-4	5.7 x 10-5	6.3 x 10-6	3.0 x 10-9	2.8 x 10-6	8.7 x 10-6
MOI	1.8 x 10-6	4.8 x 10-5	1.3 x 10-5	1.4 x 10-6	1.0 x 10-9	3.8 x 10-7	2.3 x 10-6
NPA	8.6 x 10-7	2.4 x 10-5	6.3 x 10-6	7.0 x 10-7	<1.0 x 10-9	1.9 x 10-7	1.1 x 10-6

Table F.2.4.1-4. Summary of chemical concentrations for normal operations at the Nevada Test Site.

	CHEMICAL CONCENTRATIONS mg/m3						
	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead	VOC	PM-10
Worker	9.0 x 10-5	3.6 x 10-4	4.0 x 10-4	4.5 x 10-5	7.0 x 10-9	3.8 x 10-5	4.1 x 10-5
MCW	2.5 x 10-7	7.3 x 10-6	1.9 x 10-6	2.1 x 10-7	<1.0 x 10-9	5.2 x 10-8	3.5 x 10-7
MOI	7.9 x 10-7	2.3 x 10-5	5.9 x 10-6	6.6 x 10-7	<1.0 x 10-9	1.6 x 10-7	1.1 x 10-6

Table F.2.4.1-5. Summary of chemical concentrations for normal operations at Oak Ridge.

	CHEMICAL CONCENTRATIONS mg/m3						
	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead	VOC	PM-10
Worker	6.4 x 10-5	3.0 x 10-4	2.8 x 10-4	3.1 x 10-5	5.0 x 10-9	2.6 x 10-5	2.7 x 10-5
MCW	1.6 x 10-6	2.6 x 10-5	9.6 x 10-6	1.1 x 10-6	<1.0 x 10-9	5.0 x 10-7	1.5 x 10-6
MOI	1.4 x 10-5	2.5 x 10-4	8.8 x 10-5	9.8 x 10-6	4.0 x 10-9	4.3 x 10-6	1.4 x 10-5
NPA	1.9 x 10-5	3.1 x 10-4	1.1 x 10-4	1.2 x 10-5	5.0 x 10-9	5.6 x 10-6	1.7 x 10-5

Table F.2.4.1-6. Summary of chemical concentrations for normal operations at the Barnwell Plant.

	CHEMICAL CONCENTRATIONS mg/m3						
	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead	VOC	PM-10
Worker	1.5 x 10-5	6.5 x 10-5	6.4 x 10-5	7.1 x 10-6	1.0 x 10-9	6.2 x 10-6	5.9 x 10-6
MCW	1.9 x 10-6	4.7 x 10-5	1.3 x 10-5	1.5 x 10-6	1.0 x 10-9	4.5 x 10-7	2.3 x 10-6
MOI	5.9 x 10-6	1.4 x 10-4	4.0 x 10-5	4.5 x 10-6	2.0 x 10-9	1.5 x 10-6	7.0 x 10-6
NPA	5.9 x 10-6	1.4 x 10-4	4.0 x 10-5	4.5 x 10-6	2.0 x 10-9	1.5 x 10-6	7.0 x 10-6

F.2.4.2 Accidents. **Spillage of chemicals with a subsequent fire was evaluated for the bounding** accident involving toxic chemicals. The toxic chemicals that could be involved in the postulated accident are described in Section F.2.1. As was noted in that section, the extensive listing of chemicals provided in Table F.2-1 would be applicable only at sites involved with fuel examination.

The bounding accident evaluated for spent nuclear fuel storage in water pools at shipyard locations was a diesel fuel spill and fire. A diesel fuel fire involving spent nuclear fuel shipping containers aboard a ship at sea in Puget Sound was also evaluated.

Evaluation of the chemical spill with fire accident (excluding diesel fuel) at the alternate sites (INEL-ECF, Hanford, Savannah River, Nevada Test Site, Oak Ridge, and the Barnwell Plant) where naval spent nuclear fuel examinations may be conducted is presented in Section F.2.4.2.1. Evaluation of diesel fuel fires at shipyards and aboard ship in Puget Sound, as well as at INEL-ECF, Hanford, Savannah River, Nevada Test Site, Barnwell Plant, and Oak Ridge, is described in Section F.2.4.2.2.

These accidents incorporate spillage of the entire amount of a given chemical accompanied by a fire. The initiating event might be, for example, an airplane crash or ship collision. Such an accident bounds simpler chemical spills, such as handling accidents involving limited or unit (see Table F.2-1) amounts of a chemical, which were also considered. Consequently, only results for the fire accident are provided. The analyses utilize meteorological (see Section F.1.3.5) and demographic parameters specific to the evaluated location.

The toxic chemicals evaluated in the accident analyses would be used and stored in a number of different areas within the facility. Fuel oils, sulfuric acid, and sodium hydroxide would be expected to be located outside facility buildings in storage tanks. Other chemicals used for facility support and operation would likely be stored in a variety of locations within facility buildings such as tool rooms, laboratories, craft shops, equipment rooms, chemical mixing areas, hot cells, and flammable cabinets. The probability of releasing all or most of these chemicals in a single accident such as an airplane crash would be quite low, less than 10-7 per year, as supported in Section F.3.5. However, the probability of releasing an individual or limited number of chemicals is expected to be greater than this level and include a consideration of storage locations, types, sizes, and numbers of containers, and types and frequencies of initiating events. For accidents that could result in a toxic chemical release, a probability of 5 x 10-3 per year (Ganti and Krasner 1984) was considered to be a reasonable upper level. This level was based on the probability that a structurally damaging industrial fire could occur.

F.2.4.2.1 Chemical Spill and Fire.

F.2.4.2.1.1 Accident Description. **An accident might occur which caused toxic**

chemicals to spill, dispersed powdered toxic chemicals, and accelerated the vaporization of the toxic chemicals with a subsequent fire. The airborne release resulting from the involvement of the entire available amount of the toxic chemicals was evaluated with respect to the on-site workers, MCW, NPA, and MOI.

F.2.4.2.1.2 Source Term. The toxic chemicals involved in this hypothetical accident are provided in Table F.2-1. The entire amount of the toxic chemical might be involved due to the catastrophic nature of this accident.

F.2.4.2.1.3 Conditions and Key Parameters.

(1) Gases
  - 100% of the gas was released to the atmosphere.
  - Release period was 10 minutes.
  - Release was a point source.
  - Deposition velocity was 0.1 centimeter per second.

(2) Liquids
  - 100% of the liquid was released to the atmosphere.
  - The liquid was released into a pool of 0.1-inch depth.
  - The liquid was at its boiling point.
  - The release period was the longer of the calculated evaporation time or 10 minutes.
  - Release area was equal to the pool area.
  - Deposition velocity was 0.1 centimeter per second.

(3) Solids
  - 1% of the solid was dispersed into the atmosphere as PM-10.
  - Release period was 10 minutes.
  - Release was a point source.
  - Deposition velocity was 1.0 centimeter per second.

(4) Specific Chemicals
  - CFC-12 could break down at elevated temperatures into hydrochloric acid (10%) and phosgene (1%) with the remaining (89%) released as CFC-12.
  - The hypothetical sulfuric acid spill would be contained by a berm resulting in a pool release area of 443.2 square feet.
  - The hypothetical spill of sodium hydroxide was in the form of an aqueous solution and was contained by a berm resulting in a pool release area of 374 square feet. A 10-minute period was used for this release, and the sodium hydroxide was dispersed as a particulate.

(5) Meteorology
  - Wind speeds and atmospheric stability classifications used for the calculations were based on both 50% and 95% meteorology (Section F.1.3.5) to estimate downwind concentrations. The 95% meteorology included atmospheric stability classes A through F and wind speeds from 1.1 to 30 miles per hour.

(6) General
  - Standard rural terrain was used since this most closely resembles the sites being evaluated.
  - Release was calculated to occur at ground level.
  - No evacuation of downwind populations was included, in order to obtain maximum estimates of effects; therefore, exposures were not reduced to account for this action.
  - No credit was taken for building containment or filtration.
  - Biological effects of exposure to each chemical were treated separately. This was done to account for a lack of a current methodology to evaluate the effects resulting from simultaneous multiple chemical exposures.
  - To determine health impacts, the estimated concentrations were compared against the Emergency Response Planning Guidelines (ERPG) levels 1, 2, and 3 concentration limits or alternates.
  - To determine the likelihood of developing cancer from exposure to hydrazine, a slope factor of 1.7 x 101 per mg/kg-day obtained from IRIS (TOXnet 1993) was used. In addition, the exposure time was based on the duration of the release, and individual breathing rates and sizes were the same as those used in Section F.1 for radiological accident evaluations using the Radiological Safety Analysis Computer Program (RSAC-5) (Wenzel 1993).

F.2.4.2.1.4 Results. The airborne concentrations, averaged over the duration of each exposure, were calculated using EPIcode for the alternate locations for the worker, MCW, NPA, and MOI for both 50% and 95% meteorology. The airborne concentrations were compared to respective

ERPG values where available. However, ERPG values have not been derived for some of the chemicals. The effects of these substances were assessed by comparison with other appropriate values for toxic effects as discussed in Section F.2.3.3.

Tables F.2.4.2-1 through -12 list the downwind concentrations at various locations and corresponding ERPG values (or equivalent if TLV-TWA and IDLH concentrations are available). Hydrochloric acid and phosgene, from decomposition of CFC-12, sulfuric acid, and sodium hydroxide dominate the toxic chemical effects for on-site personnel. Concentrations of these chemicals above ERPG-3 levels might result in life-threatening effects. However, in no case is an ERPG-3 level exceeded for any member of the general public except for Oak Ridge where sulfuric acid concentrations could exceed ERPG-3 levels under both 50% and 95% meteorological conditions and sodium hydroxide concentrations could exceed ERPG-3 levels under 95% meteorological conditions. For the on-site workers, collocated workers, and any member of the general public that could be exposed to toxic chemicals at levels above ERPG-3, it is expected that actual toxic chemical exposures would be much less due to the mitigative measures that would be implemented (Section F.2.4.3).

Additional information on the toxic properties for the chemicals that dominate the toxic effects is provided below.

Hydrochloric acid is a irritant to the respiratory tract, skin, eyes, and mucous membranes. More severe exposures result in pulmonary edema, and often laryngeal spasm. A concentration of 53 mg/m3 causes irritation of the throat after short exposure. Concentrations of 75-150 mg/m3 are tolerable for 1 hour; concentrations of 1,500-3,000 mg/m3 are dangerous, even for brief exposures (TOXnet 1993).

Phosgene, also known as carbonyl chloride, is a highly toxic, corrosive liquid with a low boiling point. It is toxic from intakes by inhalation, ingestion, and dermal absorption. Effects from exposure may include contact burns to the skin and eyes, shortness of breath, chest pain, severe pulmonary edema, and death. At low vapor concentrations, it smells like musty hay. At higher concentrations, it has a sharp and pungent odor. It is a severe irritant to the eyes and respiratory tract and can be fatal if inhaled, even for short durations and at low concentrations. Exposure to 12 mg/cm3 can result in immediate irritation of the respiratory tract. 80 mg/m3 may cause lung injuries within 2 minutes; 100 mg/m3 for as little as 30 minutes is very dangerous; and 360 mg/m3 is rapidly fatal for exposures of 30 minutes or less (TOXnet 1993).

Sulfuric acid mist can be strongly irritating to the skin, eyes, mucous membranes, and respiratory tract. Odor may be detected at concentrations of 1 mg/m3; irritating effects may occur at concentrations of 1.1 mg/m3. Inhalation of concentrations near 3 mg/m3 may cause constriction of the air passage and choking sensations. At higher concentrations and durations of exposure, inhalation can cause pulmonary edema, emphysema, and permanent changes in pulmonary function (TOXnet 1993).

Sodium hydroxide dust can be irritating to the upper respiratory system. Irritating effects may occur at concentrations of 2 mg/m3. At higher concentrations and durations of exposure, inhalation can cause extreme irritation of the respiratory tract and permanent changes in pulmonary function (TOXnet 1993).

Table F.2.4.2-1. Summary of chemical concentrations for chemical spill and fire at the INEL Expended Core Facility.

```
                                          CHEMICAL CONCENTRATIONS mg/m3 - 50% METEOROLOGY
                     Ethylene                                            Isopropyl
Hydrochloric                                Sulfuric                             Sodium
                           Glycol           Hydrazine                    Alcohol
Ammonia              CFC-12                   Acid                         Phosgene
Acid          Hydroquinone      Hydroxide
                           ERPG-1  127      ERPG-1  0.13                 ERPG-1  983
ERPG-1  18           ERPG-1  4950             ERPG-1  4.5                  ERPG-1  0.4
ERPG-1  2     ERPG-1  2          ERPG-1  2
                           ERPG-2  *        ERPG-2  10                   ERPG-2  2950
ERPG-2  140          ERPG-2  24750            ERPG-2  30                   ERPG-2  0.8
ERPG-2  10    ERPG-2  *          ERPG-2  25
                           ERPG-3  *        ERPG-3  100                  ERPG-3  29500
ERPG-3  700          ERPG-3  247500           ERPG-3  150                  ERPG-3  4.0
ERPG-3  30    ERPG-3  *          ERPG-3  250
Worker               3300        49               890                    38               400
45              4.5              2300       6.4          2300
MCW                  2.3          1.6 x 10-2      0.45                   1.2 x 10-2       0.12
1.3 x 10-2      1.3 x 10-3       1.4        9.3 x 10-4   0.60
MOI                  1.5          1.0 x 10-2      0.29                   7.9 x 10-3       7.7 x 10-2
8.5 x 10-3      8.5 x 10-4       0.86       5.9 x 10-4   0.39
NPA                  1.6          1.1 x 10-2      0.30                   8.3 x 10-3       8.1 x 10-2
9.0 x 10-3      9.0 x 10-4       0.91       5.9 x 10-4   0.39
```

Table F.2.4.2-2. Summary of chemical concentrations for chemical spill and fire at the INEL Expended Core Facility.

```
                                                     CHEMICAL CONCENTRATIONS mg/m3 - 95% METEOROLOGY
                        Ethylene                                                  Isopropyl
Hydrochloric                                                Sulfuric                       Sodium
                                Glycol          Hydrazine               Alcohol
Ammonia                 CFC-12                    Acid                    Phosgene
Acid          Hydroquinone     Hydroxide
                                ERPG-1  127     ERPG-1  0.13            ERPG-1  983
ERPG-1  18              ERPG-1  4950              ERPG-1  4.5             ERPG-1  0.4
ERPG-1  2     ERPG-1  2           ERPG-1  2
                                ERPG-2  *       ERPG-2  10              ERPG-2  2950
ERPG-2  140             ERPG-2  24750             ERPG-2  30              ERPG-2  0.8
ERPG-2  10    ERPG-2  *           ERPG-2  25
                                ERPG-3  *       ERPG-3  100             ERPG-3  29500
ERPG-3  700             ERPG-3  247500            ERPG-3  150             ERPG-3  4.0
ERPG-3  30    ERPG-3  *           ERPG-3  250
Worker                  4400        58              2200              150               1600
180               18              2800       7.7           2700
MCW                     7.6          4.8 x 10-2       2.6             8.3 x 10-2        0.80
8.9 x 10-2        8.9 x 10-3      3.9        2.2 x 10-3    1.5
MOI                     3.6          2.3 x 10-2       1.1             3.2 x 10-2        0.30
3.4 x 10-2        3.4 x 10-3      1.9        8.8 x 10-4    0.58
NPA                     3.6          2.3 x 10-2       1.1             3.2 x 10-2        0.30
3.4 x 10-2        3.4 x 10-3      1.9        8.8 x 10-4    0.58
```

*IDLH concentrations are not available; therefore, corresponding ERPG-2 and -3 levels could not be determined.

Table F.2.4.2-3. Summary of chemical concentrations for chemical spill and fire at Savannah River.

```
                                                      CHEMICAL CONCENTRATIONS mg/m3 - 50% METEOROLOGY
                        Ethylene                                                Isopropyl
Hydrochloric                                                Sulfuric                      Sodium
                                Glycol          Hydrazine              Alcohol
Ammonia                 CFC-12                    Acid                    Phosgene
Acid          Hydroquinone     Hydroxide
                                ERPG-1  127    ERPG-1  0.13           ERPG-1  983              ERPG-
1  18              ERPG-1  4950             ERPG-1  4.5           ERPG-1  0.4              ERPG-1
2     ERPG-1  2          ERPG-1  2
                                ERPG-2  *      ERPG-2  10             ERPG-2  2950             ERPG-
2  140             ERPG-2  24750            ERPG-2  30            ERPG-2  0.8              ERPG-2
10    ERPG-2  *          ERPG-2  25
                                ERPG-3  *      ERPG-3  100            ERPG-3  29500            ERPG-
3  700             ERPG-3  247500           ERPG-3  150           ERPG-3  4.0              ERPG-3
30    ERPG-3  *          ERPG-3  250
Worker                  1500       19                  370             14                150
16                1.6             1000       2.9           1200
MCW                     32         0.25                6.6             0.19              1.9
0.21              2.1 x 10-2      20         3.6 x 10-2    22
MOI                     1.3        8.7 x 10-3          0.24            6.7 x 10-3        6.4 x 10-2
7.2 x 10-3        7.2 x 10-4      0.88       7.2 x 10-4    0.47
NPA                     1.3        8.7 x 10-3          0.24            6.7 x 10-3        6.4 x 10-2
7.2 x 10-3        7.2 x 10-4      0.88       7.2 x 10-4    0.47
```

Table F.2.4.2-4. Summary of chemical concentrations for chemical spill and fire at Savannah River.

```
                        CHEMICAL CONCENTRATIONS mg/m3 - 95% METEOROLOGY
                        Ethylene                                                Isopropyl
Hydrochloric                                                Sulfuric                      Sodium
                                Glycol          Hydrazine              Alcohol
Ammonia                 CFC-12                    Acid                    Phosgene
Acid          Hydroquinone     Hydroxide
                                ERPG-1  127    ERPG-1  0.13           ERPG-1  983              ERPG-
1  18              ERPG-1  4950             ERPG-1  4.5           ERPG-1  0.4              ERPG-1
2     ERPG-1  2          ERPG-1  2
                                ERPG-2  *      ERPG-2  10             ERPG-2  2950             ERPG-
2  140             ERPG-2  24750            ERPG-2  30            ERPG-2  0.8              ERPG-2
10    ERPG-2  *          ERPG-2  25
                                ERPG-3  *      ERPG-3  100            ERPG-3  29500            ERPG-
3  700             ERPG-3  247500           ERPG-3  150           ERPG-3  4.0              ERPG-3
30    ERPG-3  *          ERPG-3  250
Worker                  4400       58                  2200            150               1600
180               18              2800       7.7           2700
MCW                     220        1.6                 85              4.0               39
4.3               0.43            120        0.12          72
MOI                     4.9        3.0 x 10-2          1.6             4.7 x 10-2        0.44
4.9 x 10-2        4.9 x 10-3      2.5        1.3 x 10-3    0.85
NPA                     4.9        3.0 x 10-2          1.6             4.7 x 10-2        0.44
4.9 x 10-2        4.9 x 10-3      2.5        1.3 x 10-3    0.85
```

*IDLH concentrations are not available; therefore, corresponding ERPG-2 and -3 levels could not be determined.

Table F.2.4.2-5. Summary of chemical concentrations for chemical spill and fire at Hanford.

```
                                                       CHEMICAL CONCENTRATIONS mg/m3 - 50% METEOROLOGY
```

```
                       Ethylene                                     Isopropyl
Hydrochloric                                  Sulfuric                Sodium
                              Glycol         Hydrazine              Alcohol
Ammonia                CFC-12                   Acid                   Phosgene
Acid          Hydroquinone      Hydroxide
                              ERPG-1  127    ERPG-1  0.13           ERPG-1  983            ERPG-
1  18             ERPG-1  4950             ERPG-1  4.5            ERPG-1  0.4            ERPG-1
2     ERPG-1  2         ERPG-1  2
                              ERPG-2  *      ERPG-2  10             ERPG-2  2950           ERPG-
2  140            ERPG-2  24750            ERPG-2  30             ERPG-2  0.8            ERPG-2
10    ERPG-2  *         ERPG-2  25
                              ERPG-3  *      ERPG-3  100            ERPG-3  29500          ERPG-
3  700            ERPG-3  247500           ERPG-3  150            ERPG-3  4.0            ERPG-3
30    ERPG-3  *         ERPG-3  250
Worker                 1500       19                370              14                150
16               1.6              1000       2.9               1200
MCW                    46         0.36              9.6              0.28              2.7
0.30             3.0 x 10-2       28         4.1 x 10-2   26
MOI (New ECF)**        0.73      5.1 x 10-3        8.1 x 10-2       3.9 x 10-3        3.8 x 10-2
4.2 x 10-3       4.2 x 10-4       0.44       2.3 x 10-4   0.16
MOI (FMEF)***          0.97      7.1 x 10-3        0.19             5.4 x 10-3        5.2 x 10-2
5.8 x 10-3       5.8 x 10-4       0.96       7.8 x 10-4   0.51
NPA                    1.5       9.9 x 10-3        0.29             7.9 x 10-3        7.6 x 10-2
8.5 x 10-3       8.5 x 10-4       0.86       7.3 x 10-4   0.49
```

Table F.2.4.2-6. Summary of chemical concentrations for chemical spill and fire at Hanford.

```
                                           CHEMICAL CONCENTRATIONS mg/m3 - 95% METEOROLOGY
                       Ethylene                                     Isopropyl
Hydrochloric                                  Sulfuric                Sodium
                              Glycol         Hydrazine              Alcohol
Ammonia                CFC-12                   Acid                   Phosgene
Acid          Hydroquinone      Hydroxide
                              ERPG-1  127    ERPG-1  0.13           ERPG-1  983            ERPG-
1  18             ERPG-1  4950             ERPG-1  4.5            ERPG-1  0.4            ERPG-1
2     ERPG-1  2         ERPG-1  2
                              ERPG-2  *      ERPG-2  10             ERPG-2  2950           ERPG-
2  140            ERPG-2  24750            ERPG-2  30             ERPG-2  0.8            ERPG-2
10    ERPG-2  *         ERPG-2  25
                              ERPG-3  *      ERPG-3  100            ERPG-3  29500          ERPG-
3  700            ERPG-3  247500           ERPG-3  150            ERPG-3  4.0            ERPG-3
30    ERPG-3  *         ERPG-3  250
Worker                 4400       58                2200             150               1600
180              18               2800       7.7               2700
MCW                    150        1.1               55               2.5               24
2.7              0.27             78         7.6 x 10-2   45
MOI (New ECF)**        2.1       1.3 x 10-2        0.47             1.3 x 10-2        0.13
1.4 x 10-2       1.4 x 10-3       1.1        4.1 x 10-4   0.28
MOI (FMEF)***          5.5       3.5 x 10-2        1.8              5.4 x 10-2        0.51
5.7 x 10-2       5.7 x 10-3       2.8        1.5 x 10-3   0.99
NPA                    5.3       3.3 x 10-2        1.7              5.1 x 10-2        0.48
5.4 x 10-2       5.4 x 10-3       2.7        1.4 x 10-3   0.94
```

*IDLH concentrations are not available; therefore, corresponding ERPG-2 and -3 levels could not be determined.

**MOI (New ECF) applies if spent fuel facility is constructed at the 200 Area on the Hanford Site.

***MOI (FMEF) applies if spent fuel facility is constructed at the Fuels and Materials Examination Facility.

Table F.2.4.2-7. Summary of chemical concentrations for chemical spill and fire at the Nevada Test Site.

```
                                         CHEMICAL CONCENTRATIONS mg/m3 - 50% METEOROLOGY
                       Ethylene                                      Isopropyl
Hydrochloric                                  Sulfuric                Sodium
                              Glycol          Hydrazine              Alcohol
Ammonia                CFC-12                   Acid                   Phosgene
Acid          Hydroquinone      Hydroxide
                              ERPG-1  127     ERPG-1  0.13           ERPG-1  983
ERPG-1  18             ERPG-1  4950             ERPG-1  4.5            ERPG-1  0.4
ERPG-1  2     ERPG-1  2         ERPG-1  2
                              ERPG-2  *       ERPG-2  10             ERPG-2  2950
ERPG-2  140            ERPG-2  24750            ERPG-2  30             ERPG-2  0.8
ERPG-2  10    ERPG-2  *         ERPG-2  25
                              ERPG-3  *       ERPG-3  100            ERPG-3  29500
ERPG-3  700            ERPG-3  247500           ERPG-3  150            ERPG-3  4.0
ERPG-3  30    ERPG-3  *         ERPG-3  250
Worker                 530         6.8               130              5.1               53
5.9              0.59             820        1.2               490
MCW                    0.22        1.5 x 10-3        4.1 x 10-2       1.1 x 10-3        1.1 x 10-2
1.2 x 10-3       1.2 x 10-4       0.12       2.1 x 10-4   0.14
MOI                    0.74        5.4 x 10-3        0.14             4.0 x 10-3        3.8 x 10-2
4.4 x 10-3       4.4 x 10-4       0.97       7.0 x 10-4   0.46
```

Table F.2.4.2-8. Summary of chemical concentrations for chemical spill and fire at the Nevada Test Site.

```
                                         CHEMICAL CONCENTRATIONS mg/m3 - 95% METEOROLOGY
                       Ethylene                                      Isopropyl
Hydrochloric                                  Sulfuric                        Sodium
                              Glycol          Hydrazine              Alcohol
Ammonia                CFC-12                   Acid                   Phosgene
Acid          Hydroquinone      Hydroxide
                              ERPG-1  127     ERPG-1  0.13           ERPG-1  983
ERPG-1  18             ERPG-1  4950             ERPG-1  4.5            ERPG-1  0.4
ERPG-1  2     ERPG-1  2         ERPG-1  2
                              ERPG-2  *       ERPG-2  10             ERPG-2  2950
ERPG-2  140            ERPG-2  24750            ERPG-2  30             ERPG-2  0.8
ERPG-2  10    ERPG-2  *         ERPG-2  25
                              ERPG-3  *       ERPG-3  100            ERPG-3  29500
ERPG-3  700            ERPG-3  247500           ERPG-3  150            ERPG-3  4.0
ERPG-3  30    ERPG-3  *         ERPG-3  250
Worker                 4400        58              2200              150             1600
180              18               2800       7.7          2700
MCW                    5.9         3.7 x 10-2      1.9               5.8 x 10-2      0.55
6.2 x 10-2       6.2 x 10-3       3.0        1.6 x 10-3   1.1
MOI                    7.3         4.6 x 10-2      2.5               7.8 x 10-2      0.76
8.4 x 10-2       8.4 x 10-3       3.8        2.2 x 10-3   1.4
```

*IDLH concentrations are not available; therefore, corresponding ERPG-2 and -3 levels could not be determined.

Table F.2.4.2-9. Summary of chemical concentrations for chemical spill and fire at Oak Ridge.

```
                                         CHEMICAL CONCENTRATIONS mg/m3 - 50% METEOROLOGY
                       Ethylene                                      Isopropyl
Hydrochloric                                  Sulfuric                        Sodium
                              Glycol          Hydrazine              Alcohol
Ammonia                CFC-12                   Acid                   Phosgene
Acid          Hydroquinone      Hydroxide
                              ERPG-1  127     ERPG-1  0.13           ERPG-1  983
ERPG-1  18             ERPG-1  4950             ERPG-1  4.5            ERPG-1  0.4
ERPG-1  2     ERPG-1  2         ERPG-1  2
                              ERPG-2  *       ERPG-2  10             ERPG-2  2950
ERPG-2  140            ERPG-2  24750            ERPG-2  30             ERPG-2  0.8
ERPG-2  10    ERPG-2  *         ERPG-2  25
                              ERPG-3  *       ERPG-3  100            ERPG-3  29500
ERPG-3  700            ERPG-3  247500           ERPG-3  150            ERPG-3  4.0
ERPG-3  30    ERPG-3  *         ERPG-3  250
Worker                 3300        49              890               38              400
45               4.5              2300       6.4          2300
MCW                    34          0.27            7.1               0.21            2.0
0.22             2.2 x 10-2       21         3.0 x 10-2   19
MOI                    310         2.8             68                2.1             21
2.4              0.24             190        0.38         210
NPA                    440         4.3             100               3.2             32
3.7              0.37             280        0.60         310
```

Table F.2.4.2-10. Summary of chemical concentrations for chemical spill and fire at Oak Ridge.

```
                                         CHEMICAL CONCENTRATIONS mg/m3 - 95% METEOROLOGY
                       Ethylene                                      Isopropyl
Hydrochloric                                  Sulfuric                        Sodium
                              Glycol          Hydrazine              Alcohol
Ammonia                CFC-12                   Acid                   Phosgene
Acid          Hydroquinone      Hydroxide
                              ERPG-1  127     ERPG-1  0.13           ERPG-1  983
ERPG-1  18             ERPG-1  4950             ERPG-1  4.5            ERPG-1  0.4
ERPG-1  2     ERPG-1  2         ERPG-1  2
                              ERPG-2  *       ERPG-2  10             ERPG-2  2950
ERPG-2  140            ERPG-2  24750            ERPG-2  30             ERPG-2  0.8
ERPG-2  10    ERPG-2  *         ERPG-2  25
                              ERPG-3  *       ERPG-3  100            ERPG-3  29500
ERPG-3  700            ERPG-3  247500           ERPG-3  150            ERPG-3  4.0
ERPG-3  30    ERPG-3  *         ERPG-3  250
Worker                 4400        58              2200              150             1600
180              18               2800       7.7          2700
MCW                    110         0.75            41                1.9             18
2.0              0.20             58         5.4 x 10-2   32
MOI                    930         8.4             400               22              220
24               2.4              540        0.82         410
NPA                    1300        13              590               33              340
38               3.8              790        1.3          630
```

*IDLH concentrations are not available; therefore, corresponding ERPG-2 and -3 levels could not be determined.

Table F.2.4.2-11. Summary of chemical concentrations for chemical spill and fire at the Barnwell Plant.

```
                                          CHEMICAL CONCENTRATIONS mg/m3 - 50% METEOROLOGY
                       Ethylene                                     Isopropyl
Hydrochloric                                  Sulfuric                        Sodium
                              Glycol         Hydrazine              Alcohol
Ammonia                CFC-12                   Acid                   Phosgene
Acid          Hydroquinone      Hydroxide
```

	ERPG-1 127	ERPG-1 0.13	ERPG-1 983	ERPG-1 18	ERPG-1 4950	ERPG-1 4.5	ERPG-1 0.4	ERPG-1 2	ERPG-1 2	ERPG-1 2
	ERPG-2 *	ERPG-2 10	ERPG-2 2950	ERPG-2 140	ERPG-2 24750	ERPG-2 30	ERPG-2 0.8	ERPG-2 10	ERPG-2 *	ERPG-2 25
	ERPG-3 *	ERPG-3 100	ERPG-3 29500	ERPG-3 700	ERPG-3 247500	ERPG-3 150	ERPG-3 4.0	ERPG-3 30	ERPG-3 *	ERPG-3 250
Worker	1500	19	370	14	150	16	1.6	1000	2.9	1200
MCW	0.89	6.4 x 10-3	0.17	4.9 x 10-3	4.6 x 10-2	5.2 x 10-3	5.2 x 10-4	0.83	9.0 x 10-4	0.59
MOI	6.1	4.3 x 10-2	1.2	3.4 x 10-2	0.32	3.6 x 10-2	3.6 x 10-3	4.9	4.9 x 10-3	3.2
NPA	6.1	4.3 x 10-2	1.2	3.4 x 10-2	0.32	3.6 x 10-2	3.6 x 10-3	4.9	4.9 x 10-3	3.2

Table F.2.4.2-12. Summary of chemical concentrations for chemical spill and fire at the Barnwell Plant.

CHEMICAL CONCENTRATIONS mg/m3 - 95% METEOROLOGY

	Ethylene Glycol	Hydrazine	Isopropyl Alcohol	Ammonia	CFC-12	Hydrochloric Acid	Phosgene	Sulfuric Acid	Hydroquinone	Sodium Hydroxide
	ERPG-1 127	ERPG-1 0.13	ERPG-1 983	ERPG-1 18	ERPG-1 4950	ERPG-1 4.5	ERPG-1 0.4	ERPG-1 2	ERPG-1 2	ERPG-1 2
	ERPG-2 *	ERPG-2 10	ERPG-2 2950	ERPG-2 140	ERPG-2 24750	ERPG-2 30	ERPG-2 0.8	ERPG-2 10	ERPG-2 *	ERPG-2 25
	ERPG-3 *	ERPG-3 100	ERPG-3 29500	ERPG-3 700	ERPG-3 247500	ERPG-3 150	ERPG-3 4.0	ERPG-3 30	ERPG-3 *	ERPG-3 250
Worker	4400	58	2200	150	1600	180	18	2800	7.7	2700
MCW	11	6.4 x 10-2	3.5	0.13	1.3	0.14	1.4 x 10-2	5.4	3.2 x 10-3	2.0
MOI	28	0.18	10	0.41	3.9	0.44	4.4 x 10-2	15	1.1 x 10-2	6.9
NPA	28	0.18	10	0.41	3.9	0.44	4.4 x 10-2	15	1.1 x 10-2	6.9

*IDLH concentrations are not available; therefore, corresponding ERPG-2 and -3 levels could not be determined.

In addition to comparing the airborne concentrations to their respective ERPG or other appropriate values, each substance was evaluated to determine if it has the potential for future carcinogenic health impacts. It was determined that exposure to hydrazine could result in an increased likelihood for developing cancer. Tables F.2.4.2-13 and F.2.4.2-14 provide the future potential likelihood for developing cancer from exposure to hydrazine for the worker, MCW, and MOI at the alternate locations under 50% and 95% meteorological conditions, respectively.

Table F.2.4.2-13. Future potential likelihood for developing cancer from hydrazine - 50% meteorology.

	INEL Expended Core Facilit	Savannah River	Hanford*	Nevada Test Site	Oak Ridge	Barnwell Plant
Worker	9.3 x 10-5	3.6 x 10-5	3.6 x 10-5	1.3 x 10-5	9.3 x 10-5	3.6 x 10-5
MCW	3.0 x 10-8	4.8 x 10-7	6.8 x 10-7	2.8 x 10-9	5.1 x 10-7	1.2 x 10-8
MOI	1.5 x 10-8	1.3 x 10-8	7.6 x 10-9	8.1 x 10-9	4.2 x 10-6	6.4 x 10-8

Table F.2.4.2-14. Future potential likelihood for developing cancer from hydrazine - 95% meteorology.

	INEL Expended Core Facilit	Savannah River	Hanford*	Nevada Test Site	Oak Ridge	Barnwell Plant
Worker	3.8 x 10-4	3.8 x 10-4	3.8 x 10-4	3.8 x 10-4	3.8 x 10-4	3.8 x 10-4
MCW	2.0 x 10-7	6.7 x 10-6	4.6 x 10-6	1.6 x 10-7	3.2 x 10-6	2.7 x 10-7
MOI	7.8 x 10-8	1.0 x 10-7	4.4 x 10-8	1.6 x 10-7	2.9 x 10-5	6.1 x 10-7

* MOI shown applies to new ECF if spent fuel facility is constructed at the 200 Area on the Hanford Site. A future potential carcinogenic risk of 1.1 x 10-8 (50% meteorology) and 1.2 x 10-7 (95% meteorology) applies to a spent fuel facility constructed at the Fuels and Materials Examination Facility.

F.2.4.2.2 Fire Involving Diesel Fuel.

F.2.4.2.2.1 Accident Description. A catastrophic failure of the diesel fuel storage tank

facility was postulated to occur. This could result in the spilling of the entire quantity of diesel fuel and a subsequent fire. The airborne release of toxic chemicals resulting from the fire was evaluated with respect to the on-site workers, MCW, NPA, and MOI as applicable for the accident site.

F.2.4.2.2.2 Source Term. The material involved in this accident was diesel fuel with the

fire generating the following toxic chemicals due to combustion:

- Carbon monoxide
- Oxides of nitrogen (90% nitric oxide and 10% nitrogen dioxide)
- Lead
- Sulfur dioxide.

F.2.4.2.2.3 Conditions and Key Parameters.

- For alternate DOE sites and the Barnwell Plant, the diesel fuel was stored in bulk storage tanks.
- For shipyards, the diesel fuel was stored in a portable diesel power unit.
- For the ship accident, the diesel fuel was stored in large tanks adjacent to the hold.
- For alternate DOE sites and the Barnwell Plant, 1950 gallons of diesel fuel could be spilled.
- For shipyards, 315 gallons of diesel fuel could be spilled.
- For the ship accident, 121,000 gallons of diesel fuel could be spilled.
- For all facilities, the entire quantity of diesel fuel was spilled and ignited in open air.
- For alternate DOE sites and the Barnwell Plant, the spill area was 261 square feet.
- For shipyards, the spill area was 66 square feet.
- For the ship accident, the spill area used was 4812 square feet.
- For alternate DOE sites and the Barnwell Plant, the entire amount of diesel fuel was consumed by the fire over a 2-hour period.
- For shipyards, the entire amount of diesel fuel was consumed by the fire over a 1-hour period.
- For the ship accident, the entire amount of diesel fuel was consumed by the fire over a 6-hour period.
- For all facilities, the releases per gallon of fuel burned were as follows:
  Carbon monoxide = 0.34 pound
  Oxides of nitrogen = 1.58 pounds
  Lead = 4.2 x 10-6 pound
  Sulfur dioxide = 0.105 pound.
- For alternate DOE sites, the Barnwell Plant, and shipyards, the airborne release of toxic chemicals occurred at ground level.
- For the ship accident, the airborne release of toxic chemicals occurred at 48 feet above the sea (i.e., at the middle of the flame height above the cargo hatch) for evaluation of land-based exposures. For shipboard exposures, a release height of zero was used.
- For all facilities, standard rural terrain was used and building wake effects were not considered.
- For all facilities, wind speeds and atmospheric stability classifications were based on both 50% and 95% meteorology (Section F.1.3.5).
- For all facilities, no evacuation of downwind populations occurred and the biological effects of chemical exposure act uniquely and do not affect the individual in a cumulative way.
- For all facilities, to determine the health impacts, the estimated concentrations were compared against the Emergency Response Planning Guidelines (ERPG) levels 1, 2, and 3 concentration limits or alternates.

F.2.4.2.2.4 Results. The airborne concentrations, averaged over the duration of each

exposure, were calculated using EPIcode for the combustion products resulting from the fire for the worker, MCW, NPA, and MOI (as applicable for the accident site) under both 50% and 95% meteorology. The airborne concentrations were compared to respective ERPG values where available. However, ERPG values have not been derived for some of the constituents listed. The effects of these constituents were assessed by comparison with other appropriate values for toxic effects as discussed in Section F.2.3.3.

Tables F.2.4.2-15 through -38 list the downwind concentrations at various locations and corresponding ERPG (or equivalent) values. Results for the diesel fuel fire at fuel examination sites indicate that the toxic chemical concentrations for sulfur dioxide and oxides of nitrogen may exceed ERPG-3 levels for the worker. At Savannah River and Hanford, the MCW also may be exposed to a nitric oxide concentration exceeding ERPG-3 levels under 95% meteorological conditions. The NPA and MOI exposures at all the fuel examination sites would be expected to be below ERPG-2 levels except for Oak Ridge. At this location under 95% meteorological conditions, the NPA and MOI may be exposed to concentrations of sulfur dioxide and oxides of nitrogen that exceed ERPG-3 and concentrations of carbon monoxide that exceed ERPG-2. Under 50% meteorological conditions at Oak Ridge, the NPA and MOI may be exposed to concentrations of nitric oxide that exceed ERPG-3 and concentrations of sulfur dioxide and nitrogen dioxide that exceed ERPG-2. Results for the diesel fuel fire at shipyards show that for the worker and NPA categories, the toxic chemical concentrations for sulfur dioxide and oxides of nitrogen may exceed ERPG-3 levels. For the MOI, however, these concentrations are expected to be less than the ERPG-3 levels with the exception that under 95% meteorological conditions the ERPG-3 level for nitric oxide may be exceeded at the Norfolk shipyard.
Results for the ship diesel fuel fire show that shipboard (worker) concentrations of carbon monoxide, sulfur dioxide, and oxides of nitrogen may exceed ERPG-3 levels, but the shore (MOI) concentrations are expected to be less than ERPG-3 levels. For the individuals on board the ship that might be exposed to toxic chemicals at levels above ERPG-3, it is expected that actual toxic chemical exposures would be much less due to the mitigative measures that would be implemented (Section F.2.4.3).

Additional information on the toxic properties for the chemicals that dominate the toxic effects is provided below.

Sulfur dioxide is a colorless gas with a pungent odor. It is a poison, and it is also an eye, skin, and mucous membrane irritant. It chiefly affects the upper respiratory tract and bronchi and at higher concentrations, sulfur dioxide causes respiratory paralysis (TOXnet 1993).

Nitric oxide and nitrogen dioxide occur together in dynamic equilibrium. Nitric oxide is a colorless gas, and nitrogen dioxide is a reddish brown gas. Both chemicals are eye, skin, and mucous membrane irritants and primarily affect the respiratory system. Exposure to 47 mg/m3 of nitrogen dioxide can cause respiratory irritation and chest pain, 93 mg/m3 can cause lung injuries, and 187 mg/m3 can be fatal (TOXnet 1993).

In addition to comparing the airborne concentrations to their respective ERPG or other appropriate values, each substance was evaluated to determine if it has the potential for future carcinogenic impacts. It was determined that exposure to lead could result in an increased likelihood for developing cancer. However, sufficient information to quantify this likelihood was not available in IRIS. Therefore, the concentrations of lead resulting from the accident were compared against the NAAQS value for lead. For the lead concentrations provided in Tables F.2.4.2-15 through F.2.4.2-38, no NAAQS is exceeded.

F.2.4.3 Mitigative Measures for Toxic Chemicals. Mitigative measures for potential releases of

toxic materials involve administrative controls for personnel protection and emergency response. For personnel protection, controls involve safety review committees for planned activities that establish requirements, safe work permits, and procedures for required clothing (rubber boots, gloves, face shields, eye protection) that can mitigate the effects of potential releases of toxic materials. Procedures may also require provisions for prestationing mitigative devices such as eyewash stations and emergency showers. All of the alternate facilities being evaluated employ emergency response programs to mitigate impacts of potential toxic chemical accidents to workers and the public. Emergency planning, emergency preparedness, and emergency response programs are in place and involve established resources such as warning communications, fire departments, and emergency command centers. The cargo ships used for naval spent nuclear fuel have smoke detection and fire fighting equipment on board. They also have fire suppression systems in their holds which use inert gas to smother fires. In addition, less freely available oxygen in the ship's cargo hold would tend to slow the combustion rate of the diesel fuel. Port facilities would also have available additional fire fighting equipment, public warning systems, and emergency response programs.

Table F.2.4.2-15. Summary of chemical concentrations for fire involving diesel fuel at the INEL Expended Core Facility.

CHEMICAL CONCENTRATIONS mg/m3 - 50% METEOROLOGY

	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead
	ERPG-1 29	ERPG-1 0.79	ERPG-1 31	ERPG-1 5.6	ERPG-1 0.15
	ERPG-2 172	ERPG-2 7.9	ERPG-2 *	ERPG-2 9.4	ERPG-2 70
	ERPG-3 1720	ERPG-3 39	ERPG-3 123	ERPG-3 94	ERPG-3 700
Worker	480	150	2000	220	3.9 x 10-3
MCW	0.25	7.7 x 10-2	1.0	0.11	9.5 x 10-7
MOI	0.15	4.8 x 10-2	0.65	7.3 x 10-2	6.1 x 10-7
NPA	0.16	5.0 x 10-2	0.69	7.7 x 10-2	6.1 x 10-7

Table F.2.4.2-16. Summary of chemical concentrations for fire involving diesel fuel at the INEL Expended Core Facility.

CHEMICAL CONCENTRATIONS mg/m3 - 95% METEOROLOGY

	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead
	ERPG-1 29	ERPG-1 0.79	ERPG-1 31	ERPG-1 5.6	ERPG-1 0.15
	ERPG-2 172	ERPG-2 7.9	ERPG-2 *	ERPG-2 9.4	ERPG-2 70
	ERPG-3 1720	ERPG-3 39	ERPG-3 123	ERPG-3 94	ERPG-3 700
Worker	1200	370	5100	560	4.6 x 10-3
MCW	1.45	0.45	6.1	0.68	3.0 x 10-7
MOI	0.66	0.20	2.7	0.30	4.7 x 10-8
NPA	0.66	0.20	2.7	0.30	4.7 x 10-8

* ERPG-2 level not assigned since one-tenth the IDLH level would be less than the ERPG-1 level.

Table F.2.4.2-17. Summary of chemical concentrations for fire involving diesel fuel at Savannah River.

CHEMICAL CONCENTRATIONS mg/m3 - 50% METEOROLOGY

	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead
	ERPG-1 29	ERPG-1 0.79	ERPG-1 31	ERPG-1 5.6	ERPG-1 0.15
	ERPG-2 172	ERPG-2 7.9	ERPG-2 *	ERPG-2 9.4	ERPG-2 70
	ERPG-3 1720	ERPG-3 39	ERPG-3 123	ERPG-3 94	ERPG-3 700
Worker	200	62	850	94	2.0 x 10-3
MCW	3.6	1.1	15	1.7	3.6 x 10-5
MOI	0.13	4.1 x 10-2	0.55	6.1 x 10-2	7.5 x 10-7
NPA	0.13	4.1 x 10-2	0.55	6.1 x 10-2	7.5 x 10-7

Table F.2.4.2-18. Summary of chemical concentrations for fire involving diesel fuel at Savannah River.

CHEMICAL CONCENTRATIONS mg/m3 - 95% METEOROLOGY

	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead
	ERPG-1 29	ERPG-1 0.79	ERPG-1 31	ERPG-1 5.6	ERPG-1 0.15
	ERPG-2 172	ERPG-2 7.9	ERPG-2 *	ERPG-2 9.4	ERPG-2 70
	ERPG-3 1720	ERPG-3 39	ERPG-3 123	ERPG-3 94	ERPG-3 700
Worker	1200	370	5100	560	4.6 x 10-3
MCW	49	15	200	23	6.9 x 10-5
MOI	0.90	0.28	3.8	0.42	1.1 x 10-7
NPA	0.90	0.28	3.8	0.42	1.1 x 10-7

* ERPG-2 level not assigned since one-tenth the IDLH level would be less than the ERPG-1 level.

Table F.2.4.2-19. Summary of chemical concentrations for fire involving diesel fuel at Hanford.

CHEMICAL CONCENTRATIONS mg/m3 - 50% METEOROLOGY

	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead
	ERPG-1 29	ERPG-1 0.79	ERPG-1 31	ERPG-1 5.6	ERPG-1 0.15
	ERPG-2 172	ERPG-2 7.9	ERPG-2 *	ERPG-2 9.4	ERPG-2 70
	ERPG-3 1720	ERPG-3 39	ERPG-3 123	ERPG-3 94	ERPG-3 700
Worker	200	62	840	94	2.0 x 10-3
MCW	5.2	1.6	21	2.4	4.1 x 10-5
MOI (New ECF)**	8.3 x 10-2	2.4 x 10-2	0.34	3.7 x 10-2	2.5 x 10-7
MOI (FMEF)***	0.11	3.3 x 10-2	0.44	4.9 x 10-2	8.1 x 10-7
NPA	0.16	4.8 x 10-2	0.65	7.3 x 10-2	7.6 x 10-7

Table F.2.4.2-20. Summary of chemical concentrations for fire involving diesel fuel at Hanford.

CHEMICAL CONCENTRATIONS mg/m3 - 95% METEOROLOGY

	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead
	ERPG-1 29	ERPG-1 0.79	ERPG-1 31	ERPG-1 5.6	ERPG-1 0.15
	ERPG-2 172	ERPG-2 7.9	ERPG-2 *	ERPG-2 9.4	ERPG-2 70
	ERPG-3 1720	ERPG-3 39	ERPG-3 123	ERPG-3 94	ERPG-3 700
Worker	1200	370	5100	560	4.6 x 10-3
MCW	32	9.7	130	15	3.9 x 10-5
MOI (New ECF)**	0.34	0.10	1.4	0.15	4.9 x 10-8
MOI (FMEF)***	1.0	0.32	4.3	0.48	1.5 x 10-7
NPA	0.78	0.24	3.2	0.36	5.0 x 10-7

* ERPG-2 level not assigned since one-tenth the IDLH level would be less than the ERPG-1 level.

** MOI (New ECF) applies if spent fuel facility is constructed at the 200 Area on the Hanford Site.

*** MOI (FMEF) applies if spent fuel facility is constructed at the Fuels and Materials

Examination Facility.

Table F.2.4.2-21. Summary of chemical concentrations for fire involving diesel fuel at the Nevada Test Site.

CHEMICAL CONCENTRATIONS mg/m3 - 50% METEOROLOGY

	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead
	ERPG-1 29	ERPG-1 0.79	ERPG-1 31	ERPG-1 5.6	ERPG-1 0.15
	ERPG-2 172	ERPG-2 7.9	ERPG-2 *	ERPG-2 9.4	ERPG-2 70
	ERPG-3 1720	ERPG-3 39	ERPG-3 123	ERPG-3 94	ERPG-3 700
Worker	73	22	300	34	8.3 x 10-4
MCW	2.3 x 10-2	7.0 x 10-3	9.6 x 10-2	1.1 x 10-2	2.2 x 10-7
MOI	8.0 x 10-2	2.4 x 10-2	0.33	3.7 x 10-2	7.3 x 10-7

Table F.2.4.2-22. Summary of chemical concentrations for fire involving diesel fuel at the Nevada Test Site.

CHEMICAL CONCENTRATIONS mg/m3 - 95% METEOROLOGY

	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead
	ERPG-1 29	ERPG-1 0.79	ERPG-1 31	ERPG-1 5.6	ERPG-1 0.15
	ERPG-2 172	ERPG-2 7.9	ERPG-2 *	ERPG-2 9.4	ERPG-2 70
	ERPG-3 1720	ERPG-3 39	ERPG-3 123	ERPG-3 94	ERPG-3 700
Worker	1200	370	5100	560	4.6 x 10-3
MCW	1.1	0.34	4.6	0.52	1.7 x 10-7
MOI	1.4	0.43	5.9	0.65	2.7 x 10-7

* ERPG-2 level not assigned since one-tenth the IDLH level would be less than the ERPG-1 level.

Table F.2.4.2-23. Summary of chemical concentrations for fire involving diesel fuel at Oak Ridge.

CHEMICAL CONCENTRATIONS mg/m3 - 50% METEOROLOGY

	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead
	ERPG-1 29	ERPG-1 0.79	ERPG-1 31	ERPG-1 5.6	ERPG-1 0.15
	ERPG-2 172	ERPG-2 7.9	ERPG-2 *	ERPG-2 9.4	ERPG-2 70
	ERPG-3 1720	ERPG-3 39	ERPG-3 123	ERPG-3 94	ERPG-3 700
Worker	480	150	2000	220	3.9 x 10-3
MCW	3.8	1.2	16	1.8	3.0 x 10-5
MOI	37	11	150	18	3.3 x 10-4
NPA	54	17	230	26	5.0 x 10-4

Table F.2.4.2-24. Summary of chemical concentrations for fire involving diesel fuel at Oak Ridge.

CHEMICAL CONCENTRATIONS mg/m3 - 95% METEOROLOGY

	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead
	ERPG-1 29	ERPG-1 0.79	ERPG-1 31	ERPG-1 5.6	ERPG-1 0.15
	ERPG-2 172	ERPG-2 7.9	ERPG-2 *	ERPG-2 9.4	ERPG-2 70
	ERPG-3 1720	ERPG-3 39	ERPG-3 123	ERPG-3 94	ERPG-3 700
Worker	1200	370	5100	560	4.6 x 10-3
MCW	24	7.3	98	11	2.6 x 10-5
MOI	230	70	950	110	5.3 x 10-4
NPA	340	100	1400	160	8.7 x 10-4

* ERPG-2 level not assigned since one-tenth the IDLH level would be less than the ERPG-1 level.

Table F.2.4.2-25. Summary of chemical concentrations for fire involving diesel fuel at the Barnwell Plant.

CHEMICAL CONCENTRATIONS mg/m3 - 50% METEOROLOGY

	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead
	ERPG-1 29	ERPG-1 0.79	ERPG-1 31	ERPG-1 5.6	ERPG-1 0.15
	ERPG-2 172	ERPG-2 7.9	ERPG-2 *	ERPG-2 9.4	ERPG-2 70
	ERPG-3 1720	ERPG-3 39	ERPG-3 123	ERPG-3 94	ERPG-3 700
Worker	200	62	840	94	2.0 x 10-3
MCW	9.5 x 10-2	2.9 x 10-2	0.40	4.4 x 10-2	9.3 x 10-7
MOI	0.65	0.20	2.7	0.30	5.0 x 10-6
NPA	0.65	0.20	2.7	0.30	5.0 x 10-6

Table F.2.4.2-26. Summary of chemical concentrations for fire involving diesel fuel at the Barnwell Plant.

CHEMICAL CONCENTRATIONS mg/m3 - 95% METEOROLOGY

	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead
	ERPG-1 29	ERPG-1 0.79	ERPG-1 31	ERPG-1 5.6	ERPG-1 0.15
	ERPG-2 172	ERPG-2 7.9	ERPG-2 *	ERPG-2 9.4	ERPG-2 70
	ERPG-3 1720	ERPG-3 39	ERPG-3 123	ERPG-3 94	ERPG-3 700
Worker	1200	370	5100	560	4.6 x 10-3
MCW	2.0	0.62	8.4	0.94	5.4 x 10-7
MOI	5.8	1.7	24	2.7	3.2 x 10-6
NPA	5.8	1.7	24	2.7	3.2 x 10-6

* ERPG-2 level not assigned since one-tenth the IDLH level would be less than the ERPG-1 level.

Table F.2.4.2-27. Summary of chemical concentrations for fire involving diesel fuel at Kenneth A. Kesselring Site.

CHEMICAL CONCENTRATIONS mg/m3 - 50% METEOROLOGY

	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead
	ERPG-1 29	ERPG-1 0.79	ERPG-1 31	ERPG-1 5.6	ERPG-1 0.15
	ERPG-2 172	ERPG-2 7.9	ERPG-2 *	ERPG-2 9.4	ERPG-2 70

	ERPG-3 1720	ERPG-3 39	ERPG-3 123	ERPG-3 94	ERPG-3 700
Worker	44	13	180	20	4.8 x 10-4
MOI	0.25	7.7 x 10-2	1.0	0.11	2.3 x 10-6
NPA	0.25	7.7 x 10-2	1.0	0.11	2.3 x 10-6

Table F.2.4.2-28. Summary of chemical concentrations for fire involving diesel fuel at Kenneth A. Kesselring Site.

CHEMICAL CONCENTRATIONS mg/m3 - 95% METEOROLOGY

	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead
	ERPG-1 29	ERPG-1 0.79	ERPG-1 31	ERPG-1 5.6	ERPG-1 0.15
	ERPG-2 172	ERPG-2 7.9	ERPG-2 *	ERPG-2 9.4	ERPG-2 70
	ERPG-3 1720	ERPG-3 39	ERPG-3 123	ERPG-3 94	ERPG-3 700
Worker	500	150	2100	230	1.9 x 10-3
MOI	3.9	1.2	17	1.8	3.1 x 10-6
NPA	3.9	1.2	17	1.8	3.1 x 10-6

* ERPG-2 level not assigned since one-tenth the IDLH level would be less than the ERPG-1 level.

Table F.2.4.2-29. Summary of chemical concentrations for fire involving diesel fuel at Norfolk Naval Shipyard.

CHEMICAL CONCENTRATIONS mg/m3 - 50% METEOROLOGY

	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead
	ERPG-1 29	ERPG-1 0.79	ERPG-1 31	ERPG-1 5.6	ERPG-1 0.15
	ERPG-2 172	ERPG-2 7.9	ERPG-2 *	ERPG-2 9.4	ERPG-2 70
	ERPG-3 1720	ERPG-3 39	ERPG-3 123	ERPG-3 94	ERPG-3 700
Worker	44	13	180	20	4.8 x 10-4
MOI	4.3	1.3	18	2.0	4.7 x 10-5
NPA	4.3	1.3	18	2.0	4.7 x 10-5

Table F.2.4.2-30. Summary of chemical concentrations for fire involving diesel fuel at Norfolk Naval Shipyard.

CHEMICAL CONCENTRATIONS mg/m3 - 95% METEOROLOGY

	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead
	ERPG-1 29	ERPG-1 0.79	ERPG-1 31	ERPG-1 5.6	ERPG-1 0.15
	ERPG-2 172	ERPG-2 7.9	ERPG-2 *	ERPG-2 9.4	ERPG-2 70
	ERPG-3 1720	ERPG-3 39	ERPG-3 123	ERPG-3 94	ERPG-3 700
Worker	500	150	2100	230	1.9 x 10-3
MOI	47	14	200	22	2.8 x 10-4
NPA	47	14	200	22	2.8 x 10-4

* ERPG-2 level not assigned since one-tenth the IDLH level would be less than the ERPG-1 level.

Table F.2.4.2-31. Summary of chemical concentrations for fire involving diesel fuel at Pearl Harbor Naval Shipyard.

CHEMICAL CONCENTRATIONS mg/m3 - 50% METEOROLOGY

	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead
	ERPG-1 29	ERPG-1 0.79	ERPG-1 31	ERPG-1 5.6	ERPG-1 0.15
	ERPG-2 172	ERPG-2 7.9	ERPG-2 *	ERPG-2 9.4	ERPG-2 70
	ERPG-3 1720	ERPG-3 39	ERPG-3 123	ERPG-3 94	ERPG-3 700
Worker	200	61	830	92	1.6 x 10-3
MOI	3.3	1.0	13	1.5	1.7 x 10-5
NPA	12	3.6	49	5.4	1.4 x 10-4

Table F.2.4.2-32. Summary of chemical concentrations for fire involving diesel fuel at Pearl Harbor Naval Shipyard.

CHEMICAL CONCENTRATIONS mg/m3 - 95% METEOROLOGY

	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead
	ERPG-1 29	ERPG-1 0.79	ERPG-1 31	ERPG-1 5.6	ERPG-1 0.15
	ERPG-2 172	ERPG-2 7.9	ERPG-2 *	ERPG-2 9.4	ERPG-2 70
	ERPG-3 1720	ERPG-3 39	ERPG-3 123	ERPG-3 94	ERPG-3 700
Worker	500	150	2100	230	1.9 x 10-3
MOI	11	3.4	47	5.3	1.4 x 10-5
NPA	500	150	2100	230	1.9 x 10-3

* ERPG-2 level not assigned since one-tenth the IDLH level would be less than the ERPG-1 level.

Table F.2.4.2-33. Summary of chemical concentrations for fire involving diesel fuel at Portsmouth Naval Shipyard.

CHEMICAL CONCENTRATIONS mg/m3 - 50% METEOROLOGY

	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead
	ERPG-1 29	ERPG-1 0.79	ERPG-1 31	ERPG-1 5.6	ERPG-1 0.15
	ERPG-2 172	ERPG-2 7.9	ERPG-2 *	ERPG-2 9.4	ERPG-2 70
	ERPG-3 1720	ERPG-3 39	ERPG-3 123	ERPG-3 94	ERPG-3 700
Worker	33	10	140	15	3.6 x 10-4
MOI	1.7	0.51	7.0	0.78	1.7 x 10-5
NPA	2.7	0.83	11	1.2	3.0 x 10-5

Table F.2.4.2-34. Summary of chemical concentrations for fire involving diesel fuel at Portsmouth Naval Shipyard.

CHEMICAL CONCENTRATIONS mg/m3 - 95% METEOROLOGY

	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead
	ERPG-1 29	ERPG-1 0.79	ERPG-1 31	ERPG-1 5.6	ERPG-1 0.15
	ERPG-2 172	ERPG-2 7.9	ERPG-2 *	ERPG-2 9.4	ERPG-2 70
	ERPG-3 1720	ERPG-3 39	ERPG-3 123	ERPG-3 94	ERPG-3 700

Worker	500	150	2100	230	1.9 x 10-3
MOI	24	7.2	99	11	3.7 x 10-5
NPA	73	22	300	34	1.7 x 10-4

* ERPG-2 level not assigned since one-tenth the IDLH level would be less than the ERPG-1 level.

Table F.2.4.2-35. Summary of chemical concentrations for fire involving diesel fuel at Puget Sound Naval Shipyard.

CHEMICAL CONCENTRATIONS mg/m3 - 50% METEOROLOGY

	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead
	ERPG-1 29	ERPG-1 0.79	ERPG-1 31	ERPG-1 5.6	ERPG-1 0.15
	ERPG-2 172	ERPG-2 7.9	ERPG-2 *	ERPG-2 9.4	ERPG-2 70
	ERPG-3 1720	ERPG-3 39	ERPG-3 123	ERPG-3 94	ERPG-3 700
Worker	33	10	140	15	3.6 x 10-4
MOI	1.5	0.47	6.3	0.71	1.5 x 10-5
NPA	13	4.0	54	6.1	1.4 x 10-4

Table F.2.4.2-36. Summary of chemical concentrations for fire involving diesel fuel at Puget Sound Naval Shipyard.

CHEMICAL CONCENTRATIONS mg/m3 - 95% METEOROLOGY

	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead
	ERPG-1 29	ERPG-1 0.79	ERPG-1 31	ERPG-1 5.6	ERPG-1 0.15
	ERPG-2 172	ERPG-2 7.9	ERPG-2 *	ERPG-2 9.4	ERPG-2 70
	ERPG-3 1720	ERPG-3 39	ERPG-3 123	ERPG-3 94	ERPG-3 700
Worker	500	150	2100	230	1.9 x 10-3
MOI	21	6.5	89	9.8	3.2 x 10-5
NPA	200	61	830	92	5.8 x 10-4

* ERPG-2 level not assigned since one-tenth the IDLH level would be less than the ERPG-1 level.

Table F.2.4.2-37. Summary of chemical concentrations for fire involving diesel fuel aboard ship in Puget Sound.

CHEMICAL CONCENTRATIONS mg/m3 - 50% METEOROLOGY

	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead
	ERPG-1 29	ERPG-1 0.79	ERPG-1 31	ERPG-1 5.6	ERPG-1 0.15
	ERPG-2 172	ERPG-2 7.9	ERPG-2 *	ERPG-2 9.4	ERPG-2 70
	ERPG-3 1720	ERPG-3 39	ERPG-3 123	ERPG-3 94	ERPG-3 700
Worker	900	280	3800	420	9.9 x 10-3
MOI	4.0	1.2	17	1.9	4.1 x 10-5

Table F.2.4.2-38. Summary of chemical concentrations for fire involving diesel fuel aboard ship in Puget Sound.

CHEMICAL CONCENTRATIONS mg/m3 - 95% METEOROLOGY

	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead
	ERPG-1 29	ERPG-1 0.79	ERPG-1 31	ERPG-1 5.6	ERPG-1 0.15
	ERPG-2 172	ERPG-2 7.9	ERPG-2 *	ERPG-2 9.4	ERPG-2 70
	ERPG-3 1720	ERPG-3 39	ERPG-3 123	ERPG-3 94	ERPG-3 700
Worker	9900	3100	41000	4600	3.8 x 10-2
MOI	28	8.8	120	13	1.7 x 10-4

* ERPG-2 level not assigned since one-tenth the IDLH level would be less than the ERPG-1 level.

F.3 AIRCRAFT CRASH PROBABILITiES

F.3.1 Introduction

The probability of an airplane crashing into a fuel storage area or a file! examination facility at the various alternate site locations is presented in this section. An airplane crash into these regions is of concern since it might result in the release of corrosion products from the stored fuel or the release of radioactive fission products from the fuel. The method outlined in ~A Methodology for Calculation of the Probability of Crash of an Aircraft into Structures in Weapon Storage Areas" (Sandia 1983) has been ~sed to predict the crash probabilities for this analysis. This calculational methodology takes into consideration the crash probabilities associated with landing and takeoff operations at nearby airports and crashes during in-flight operations.

The aircraft crash probability analysis presented herein is based on the examination of large civilian aircraft and military aircraft crossing the space within a 10-mile radius of each site. The crash probability of general aviation aircraft is not included in this assessment since aircraft of this type generally do not possess sufficient mass or attain sufficiently high velocities to produce a serious radiological threat in the event that they crash into a fuel storage area or a fuel examination facility. Further, the crash probability contribution due to air travel beyond 10 miles was determined to be very small based on the models and conditions used in this analysis, and therefore has been omitted.

F.3.2 Methodology

The Sandia report provides the methodology which has been used for this assessment (Sandia 1983). In this report, the following expressions are given for calculating the crash probability associated with takeoff and landing operations at a given airport runway, and in-flight operations along a given airway:

Pto= ENi * Pnto * A * c(a)* e- lxijl/0(x,a) * e- lyijl/0(y,a)
Pl= ENil * Pnl * A * c(a) * e- lxijl/0(x,a) * e- lyijl/0(j,a)
Pif= ENk * Pnif * A * c(if) * e- lxkjl/0(x,if)

where: subscript "to" refers to airport takeoff operations
subscript "l" refers to airport landing operations
subscript "if" refers to in-flight operations
Ni = the number of runway operations per year
Nk = the number of in-flight operations per year
Pn = the crash probability per operation given in Table F.3-1
= the perpendicular distance from the centerline of the runway to the target in miles
= the perpendicular distance from the airway to the target in miles
= the perpendicular distance from the end of the runway to the target in miles
c(a) = crash density constant given in Table F.3-2
c(if) = crash density constant given in Table F.3-3
0(x,a) = crash density constant given in Table F.3-2
0(y,a) = crash density constant given in Table F.3-2
e(x,if) = crash density constant given in Table F.3-3
A = effective crash area in square miles.

Table F.3-1. Crash parameter Pn. Table F.3-2. Crash density constants. Table F.3-3. Crash density constants. Figure F.3-1. Crash zones. Using these relationships, the crash probability for takeoff, landing, and in-flight operations is the product of the number of operations per year, times the crash probability per operation per year, times the effective crash area per square mile, times the crash probability density per square statute mile. To determine the crash probability associated with a given site requires the repeated application of these relationships for each airport runway and for each airway. These individual crash components are then summed to arrive at a total overall crash probability for a site.

In the Sandia report, the effective crash area is identified as the sum of the effective skid area of the plane, the effective plan view associated with the target, and the effective shadow area of the crash (Sandia 1983). The following expression relates these terms and is valid for crash attitude angles greater than zero. If the crash attitude angle is zero, an airplane would be flying along parallel to the ground at an altitude equal to or greater than the height of the target; therefore, the airplane would clear the object and there would be no crash.

A = (L + A,) * (W + 5k + H * cot)

where: L - target length dimension
W - target width dimension
H - target height
A, - aircraft wingspan
- crash attitude angle
Sk - aircraft skid distance.

F.3.3 Site Specific Information

The existence and location of airports and airways within 10 statute miles of a site have been obtained from Sectional Aeronautical Maps published by the National Oceanic and Atmospheric Administration (NOAA), and from detailed site specific maps which identify nearby airports (NOAA 1993a; NOAA 1993b; NOAA 1993e; NOAA 1993d; NOAA 1993e; NOAA 1993f; NOAA 1993g; USGS 1983a; USGS 1983b). These same sources of information were also used to obtain the distances from airport runways and airways to the sites of interest. Information regarding air traffic along airways within this region was obtained from the Federal Aviation Administration

(FAA). Airplane holding paflerns and approach and departure routes that were identified by the FAA were converted into equivalent airways for this analysis. Information regarding the number of takeoff and landing operations at each airport runway was obtained from the cogniaant airport officials (i.e., airport manager or base commander), or from the FAA. Tables F.34 and F.3-S summarize the airport and airway traffic information that was obtained.

Table F.3-4. Airport landings and takeoffs per site location per year. Table F.3-5. Airway air traffic per site location per year.

The effective crash area associated with various types of fliel storage at shipyards and prototypes was based on the storage facility footprints identified in Table D-1 of Attachment D. Length and width dimensions associated with the target area were calculated from these footprints by treating the storage area as square (i.e., equal length and width dimensions). The height of the dry storage containers was based on that of an existing M-140 shipping container, and the height of the water pool facility superstructure was based on the approximate height of the Expended Core Facility at INEL. For the water pool facility, a crash into the building might damage the fliel either by the airplane directly striking it or by the airplane causing sufficient damage to the building to cause part of the building structure to collapse and strike the fliel. The crash attitude angle used was 15 degrees, based on the recommended value identified in the Sandia report (Sandia 1983). A reduced aircraft skid distance of 300 feet was used. This skid distance is based on a review of the proposed site locations and reflects the fact that nearby buildings, dry docks, or retaining walls will generally limit the length of the aircraft skid to 300 feet or less prior to impact.

The effective crash area associated with fuel examination at the Expended Core Facility at INEL or similar facilities to be constructed at the Barnwell Plant, Hanford, Oak Ridge, the Nevada Test Site, or Savannah River was based on the vulnerable part of the facility being 667 feet long, 194 feet wide, and 60 feet high. This represents the portion of the Expended Core Facility that contains the combined dry cell, shielded cell, and water pool as identified in Attachment B. For these facilities, a crash into the building might damage the fuel either by the airplane directly striking it or by the airplane causing sufficient damage to the building to cause part of the building structure to collapse and strike the fuel. The effective crash area associated with dry storage or shipping containers waiting to be handled at these fuel examination facilities is based on the height and width of an existing M-140 shipping container and the modeling approach that two such containers could be located outside of the fuel processing facility and separated by a reasonably large distance. The crash attitude angle that was used was 15 degrees. For these facilities and containers, airplane skid distances of 2200 feet for military high performance aircraft and 1600 feet for large military and large civilian aircraft were used. These skid distances correspond to the maximum expected skid distance based on the information presented in the Sandia report (Sandia 1983).

F.3.4 Aircraft Specific Information

Aircraft wingspans which are representative of large civilian aircraft, military high performance aircraft (i.e., tactical fighter and tactical fighter trainer), and large military aircraft (i.e., cargo, transport, refueling, and bomber) have been taken into account separately in computing the overall crash probabilities for each site. Wingspans for these three class of aircraft have been based on average values computed from individual planes within each class. Data from "Aviation Week & Space Technology" served as the basis for determining these wingspans (AWST 1992). The calculated average wingspans were: 40 feet for military high-performance aircraft, 131 feet for large military aircraft, and 135 feet for large civilian aircraft. For large military and civilian aircraft, an effective wingspan that was 75% of the average wingspan was used in the probability calculations. This effective wingspan reflects the fact that only the region between the most outboard wing-mounted engines has the potential to seriously damage a fuel storage area or a fuel examination facility.

F.3.5 Results

Tables F.3-6 and F.3-7 present the crash probability results for the four methods of fuel storage at shipyards and prototypes and for fuel examination facilities. The probabilities listed within these tables represent the combined takeoff, landing, and in-flight crash probabilities associated with each method of fuel storage at each site. Following the DOE NEPA oversight guidance, consequences for beyond design basis accidents are calculated where the probability is 10(-7) or greater per year. These consequences are discussed in Section F. 1.4 of this attachment. For cases less likely than 10(-7) per year, calculations of consequences are not included.

The probability calculated for airplane crashes at different facilities located within a particular DOE site may vary somewhat. This situation exists at INEL where low altitude testing of commercial jet airliners has been conducted near the NOAA tower. This tower is located about 1.5 miles from ICPP, and 2.3 miles from ECF. As a result of this difference in distance, the crash probabilities are expected to be about a factor of two higher at ICPP than at ECF. Further, two different methodologies have been in general use for determination of aircraft accident probabilities. In addition to the Sandia methodology used in this appendix, a technique developed by the NRC in the 1970's has been applied at some facilities. Comparison of the two methods has shown that results can differ by a factor of two to four, with the NRC method generally producing higher probabilities than the Sandia method. This difference stems from the somewhat more detailed nature of the Sandia method. Therefore, calculated aircraft crash probabilities at ICPP are expected to be about a factor of four to eight higher than those calculated for ECF.

Crash probabilities fall in the design basis range (i.e., probability of occurrence > 10(-7) per year) at Pearl Harbor for all types of fuel storage, at Norfolk for fuel storage in shipping containers on railcars, and at Oak Ridge and Savannah River for the fuel examination facility dry cell and water pool. The radiological consequences associated with an airplane crash into these areas are addressed in detail in Section F.1.4.

Crash probabilities fall in the beyond design basis range (i.e., probability of occurrence between 10(-6) and 10(-7) per year) at Norfolk for fuel storage in immobile dry storage containers, shipping containers on a concrete pad, and in the water pool facility, at Kesselring for fuel storage in shipping containers on railcars and in the water pool facility, at Portsmouth for shipping containers on railcars, at the Nevada Test Site for the fuel examination facility dry cell and water pool, and the fuel examination facility dry storage containers at Oak Ridge and Savannah River. The radiological consequences associated with an airplane crash into these areas are also addressed in detail in Section F.1.4.

Crash probabilities with a likelihood of occurrence less than 10(-7) per year are not evaluated since it is expected that they would contribute very very little to the risk. This is the case for immobile dry storage and shipping containers on a concrete pad at Kesselring and Portsmouth, the water pool facility at Portsmouth, all types of flid storage at Puget Sound, the fuel examination facilities at Barnwell, Hanford, and INEL, and the fuel examination facility dry storage containers at the Nevada Test Site.

F.4 FUGITIVE DUST

Table F.3-6. Crash probabilities for various fuel storage options per site location per year.

Table F.3-7. Crash probabilities for fuel examination facilities per site location per year.

The INEL-ECF is a large laboratory facility used to receive, examine, and ship naval nuclear fuel and irradiated test specimen assemblies. This section provides the results of an evaluation of fugitive dust emissions that could be generated during the construction of a similar laboratory facility at an alternate location (Hanford, Savannah River, the Nevada Test Site, the Barnwell Plant, or Oak Ridge).

F.4.1 Computer Modeling to Estimate Fugitive Dust Emissions

Factors such as locations of affected persons, terrain, meteorological conditions, release conditions, and grain size distributions are required as input parameters for calculations to determine particulate concentrations from fugitive dust emissions during construction activities. This section describes the computer model used to perform fugitive dust concentration estimates. Specific input parameters used in this analysis are summarized in Section F.4.2.

The Fugitive Dust Model (FDM) was the computer code chosen to evaluate fugitive dust emissions from construction activities at an alternate DOE location. FDM is a computerized air quality model specifically designed for estimating fugitive dust emissions from point, line, or area sources (EPA 1992c).

FDM is designed to work with properly prepared meteorological data such as the EPA RAMMET program or card images of meteorological data in either hourly or Stability Array (STAR) format. FDM is based on the well-known Gaussian plume formulation for computing concentrations, but the model has been specifically adapted to incorporate an improved gradient transfer deposition algorithm. Emissions for each source are apportioned by the user into a series of particle size classes. A gravitational settling velocity and a deposition velocity are subsequently calculated by FDM for each class, and dust concentrations and depositions are then calculated for locations selected by the user.

FDM is the preferred model for estimating conditions resulting from particulate matter emissions from fugitive sources such as excavation and soil handling. The ISC2 Code (Section F.2.2.2) can also be used for this purpose; however, FDM was judged to be superior to the ISC2 Code for this evaluation.

F.4.2 Conditions and Key Parameters

- Construction area was 30 acres
- Construction activities occurred over a 3- to 5-year period.
- An emission factor of 2.0 tons per acre-month was used.
- Grain sizes used were as follows:

Average Diameter (um)	% of Total
1.25	3
3.75	5
7.5	15
12.5	10
20.0	67

- Meteorological conditions used were the 5-year average STAR data sets.
- Roughness heights were 2 centimeters for Hanford and Nevada Test Site and 30 centimeters for Savannah River, the Barnwell Plant, and Oak Ridge.

F.4.3 Results

The fugitive dust concentrations were calculated using FDM for the worker, MCW, NPA, and MOl using normal meteorology. Table F.4-1 lists the fugitive dust concentrations at various locations. These airborne concentrations were compared against the TLV-TWA concentration for particulates. The TLV-TWA concentration of 10 mg/m3 was not exceeded at any of the specified locations for fugitive dust that could be generated during construction activities at the alternate locations. Since these concentrations were extremely low, it can also be concluded that similar results would be expected for the alternate shipyard locations since the facilities to be constructed would be smaller.

F.5 OCCUPATIONAL ACCIDENTS

Table F.4-1. Summay of fugutive dust concentrations for construction activities at alternate locations.

Occupational accidents can occur in the workplace during the construction or operation of any industrial facility. In order to assess the possible extent of occupational accidents during construction and non~nstruction operations at naval spent nuclear fuel facilities, projections of the number of fatalities and injuries or illnesses were made for each alternative. The projections are presented in this section. The projections are based on average occupational fatality and injury incidence rate data published by the DOE (DOE 1993a) for DOE and DOE contractor operations. The incidence rates that were used in the analyses are provided below. A more detailed discussion of the basis for these incidence rates is presented in Volume 1.

Average occupational injury/illness and fatality rates (a)

	All Labor Categories		Construction Workers	
	Total Injury/Illness	Fatalities	Total Injury/Illness	Fatalities
DOE and Contracters(b)	3.2	0.0032	6.2	0.011

(a) All incidence rates are given per 100 worker-years

(b) 1988-1992 averages (DOE 1993a)

The term "injury/illness" as used in this analysis corresponds to the DOE definition of a recordable injury illness. Specifically, an injury or illness case represents any work-related death, illness, or any work-related injury which would result in loss of consciousness, restriction of work or motion, transfer to another job, or medical treatment beyond first aid.

F.5.1 Accident Evaluation

F.5.1.1 Constiuction. The average number of construction-related fatalities and injury or illnesses

and the 4o-year total were calculated. The methods of calculating construction-related fatalities and injuries or illnesses are presented below.

The number of construction workers that would be required to construct or modify each naval spent nuclear fuel storage and examination facility was calculated for every year that construction would take place during the period 1995 through 2035. The sum of these workers represents the total number of construction workers. The 40-year total of construction fatalities was obtained by multiplying the total number of construction workers by the construction fatality rate for DOE and DOE contractors.

The annual average number of construction workers for each facility was obtained by dividing the total number of construction workers by the number of years that construction would take place. The product of the annual average number of construction workers and the construction fatality rate for DOE and DOE contractors was calculated to provide the annual average number of construction fatalities.

The annual average and 40-year total construction injuries or illnesses were calculated in the same manner as construction fatalities except that the construction injury or illness accident rate for DOE and DOE contractors.

F.5.1.2 Storage end Examination Facillty Operations. The average number of fatalities and

injuries or illnesses and the 40-year total fatalities and injuries or illnesses were calculated for operation of naval spent nuclear fuel storage and examination facilities. The methods of calculating the operational fatalities and injuries or illness are presented below.

The accident rates for DOE and DOE contractor operations other than construction were used because examination and storage facility operations would more likely be performed by DOE and DOE contractor personnel (or Navy personnel in the case of shipyards). The number of workers that would be required to operate each naval spent nuclear fuel storage and examination facility was calculated for every year during the period 1995 through 2035 and summed over the 40-year period to obtain the total number of workers. The 40-year total of fatalities was obtained by multiplying the total number of workers by the DOE fatality rate.

The annual average number of workers for each facility was obtained by dividing the total number of workers by the number of operational years (40 years). The product of the annual average number of workers and the DOE fatality rate represents the annual average number of operational fatalities.

The annual average and 40-year total estimated injuries or illnesses associated with facility operations were calculated in the same manner as fatalities associated with facility operations except that the DOE injury or illness accident rate was used.

F.5.2 Results

This section presents tabulated results of calculations of construction and operating fatalities and injuries or illnesses for each alternative. Table F.5-1 provides the projections of occupational fatalities and injuries or illnesses for construction activities and storage and examination operations for each alternative. Tables F.5-2 through F.5-3 present the results of calculations of occupational fatalities and injuries or illnesses for construction activities and storage and examination operations at naval sites. The results of all calculations show that the number of fatalities and injuries or illnesses for construction activities and storage and examination operations would be low for any alternative.

Table F.5-1. Occupational facilities and injury/illnesses by alternative-construction activities and storage and examination facility operations.

Table F.5-2. Occupational facilities for construction activities at Naval Nuclear Propulsion Program sites.

Table F.5-3. Occupational fatalities for storage and examination facility operations at Naval Nuclear Propulsion Program sites.

Table F.5-4. Occupational injuries/illnesses for construction activities at Naval Nuclear Propulsion Program sites.

Table F.5-5. Occupational injuries/illnesses for storage and examination facility operations at Naval Nuclear Propulsion Program sites.

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ATTACHMENT G

COMPARISON OF THE NAVAL SPENT NUCLEAR FUEL STORAGE ENVIRONMENTAL ASSESSMENT AND THIS ENVIRONMENTAL IMPACT STATEMENT

The Naval Nuclear Propulsion Program has prepared an environmental assessment of short-term storage of naval spent nuclear fuel until the environmental impact statement, of which this appendix is a part, can be completed and an alternative for management of naval spent nuclear fuel is selected (Federal Register, Vol. 59, No. 19, 4051, January 8, 1994). The environmental assessment considered alternatives for storing, until June 1995, naval spent nuclear fuel removed from nuclear-powered vessels and reactor prototypes at several naval sites. The environmental impact statement, which the appendix including this attachment is a part, considers alternatives for the examination and storage of naval spent nuclear fuel during a 40-year period beginning in June 1995.

Occasions may arise when comparison of the impacts for naval spent nuclear fuel described in these two documents may be desired. However, there are some differences between the environmental assessment and this appendix which should be recognized because they make such a comparison complicated. Failure to recognize these differences may lead to an erroneous conclusion that the two documents are inconsistent or contradictory.

First, and most importantly, the environmental assessment considered only a limited period, less than 2 years, needed to conduct the National Environmental Policy Act process required to reach a decision on the long-term management of Department of Energy (DOE) spent nuclear fuel. This process includes preparation of this environmental impact statement. The environmental impact statement, and therefore this appendix, provides the evaluation of the alternatives to be used for managing spent nuclear fuel for 40 years. As a result, this environmental impact statement considers a wider range of alternatives than the environmental assessment, partly because more alternatives are possible if a longer time is available to implement them and partly because some decisions which could be deferred for a short period such as 2 years should not be deferred for a period as long as 40 years.

The alternatives considered in the environmental impact statement also include more potential sites for management of naval spent nuclear fuel. This provides a wider range of choices, but, as a natural consequence, it also increases the number of potential destinations and the miles traveled by shipments of naval spent nuclear fuel under some alternatives. In the same manner, while the environmental assessment considered temporary storage of naval spent nuclear fuel at Newport News Shipbuilding, storage at Newport News is not included in the alternatives in the environmental impact statement because that shipyard is not federally owned.

The alternatives considered in the environmental impact statement also include storage of naval spent nuclear fuel in water pools and immobile dry storage casks in addition to storage in shipping containers. There is also an evaluation of alternatives for examination of naval spent nuclear fuel in the environmental impact statement. These additional storage modes and examination alternatives were not considered in detail in the environmental assessment because the period covered by that document was short and consequently, the implementation of some of the alternatives would have been impractical. For example, water pool storage facilities could not be funded and constructed at the shipyards in a period of less than 2 years.

Also, as a natural result of the longer period considered in this environmental impact statement, a larger number of naval spent nuclear fuel assemblies and additional types of naval fuel assemblies are included in the analyses. The increase in the amount of naval spent nuclear fuel occurs since a certain number of naval reactors are refueled or defueled each year, so in a greater number of years more fuel becomes available for storage. Similarly, some newer designs for naval nuclear propulsion plants will not be refueled for the first time until some time after 1995, so those types of fuel are not treated in the environmental assessment.

The environmental impact statement addresses some impacts of normal operations and some accidents not discussed in the environmental assessment because the conditions or operation which might cause these effects would not occur under the alternatives considered in the environmental assessment. The environmental impact statement also addresses several types of impacts for each alternative in greater detail than the environmental assessment. This was done because more detailed treatment was judged to be appropriate with the broader scope of alternatives in the environmental impact statement.

The methods used to perform the analyses in the environmental impact statement have been refined in the time since the environmental assessment was prepared. This occurred partly because of the larger number of naval spent nuclear fuel assemblies analyzed and the wider scope of sites and methods of storage to be evaluated, and partly because additional time was available to implement the refinements. In addition to refinements in the methods for performing the calculations, some minor changes in the calculational models were made in order to establish a high degree of consistency with the analytical methods used for the other DOE sites that are part of the environmental impact statement. This consistency is appropriate in some cases in order to establish common grounds for comparison of alternatives. The changes in the calculational methods make a direct comparison of the analytical results presented in the environmental assessment for naval sites with those in this appendix difficult.

GLOSSARY

activation	The process of making a material radioactive by exposing the material to neutrons, protons, or other nuclear particles.
activation products	The radionuclides formed as a result of a material being activated. For example, cobalt-60 is an activation product resulting from neutron activation of cobalt-59.
activity	A measure of the rate at which a material is emitting nuclear radiation. Activity is usually measured in terms of the number of nuclear disintegrations which occur in a quantity of the material over a period of time. The standard unit of activity is the curie (Ci), which is equal to 37 billion (3.7 x 1010) disintegrations per second.
aggregates	Sand, gravel, or rock which is used in concrete or mortar mixes to achieve increased strength.
airborne emissions	Radioactivity in the form of radioactive particles, gases, or both that is transported by air.
alloy	A mixture of two or more metals.
aquifer	A water-bearing stratum of permeable rock, sand, or gravel located beneath the surface of the earth, which is capable of yielding water to a well or spring.
archaeological areas	Areas of or relating to the scientific study of material remains (as fossil relics, artifacts, monuments) of past human life and activities.
average individual	An individual who could consume items or occupy areas at rates which would be typical for the population of interest.
base flood	A flood which has a 1-percent chance of occurrence in any given year. Also referred to as a 100-year flood.
benthic	Pertaining to the bottom of the ocean.
best estimate	An estimate in which the factors used in determining the estimate were chosen such that the result approximately represents what would be expected.
cladding	A metal casing that surrounds the nuclear fuel.
coastal zone	The region along the shore, adjacent to the ocean. A coastal zone is usually defined as the region within 3 nautical miles of a shoreline.
concentration factor	A factor which is defined as the concentration of an element or radionuclide in an organism or its tissues divided by the concentration directly available from the organism's environment under equilibrium or steady-state conditions.

conservative estimate	An estimate in which the factors used in determining the estimate were chosen such that the result would be unlikely to be exceeded.
containments	Devices as complex as a glove box or as simple as a plastic bag designed to limit the spread of radioactive contamination to an area as close as possible to the source, and to break the chain of transfer to prevent contaminating other material.
core	The central portion of a nuclear reactor containing the nuclear fuel.
corrosion	The process denoting the destruction of metal by chemical or electrochemical action.
corrosion products	The substances produced by corrosion of a metal. Rust is a common corrosion product resulting from the corrosion of iron.
corrosion-resistant alloy	An alloy which corrodes slowly compared to ordinary alloys. Stainless steel is an example of a corrosion-resistant alloy.
critical organ	The limiting organ for evaluating exposure to ionizing radiation. A critical organ is determined by the following criteria: (1) the organ that accumulates the greatest concentration of a radioactive material, (2) the necessity of the organ to the well being of the entire body, (3) the organ most damaged by the entry of a radionuclide into the body, and (4) the organ damaged by the lowest exposure. Usually, case (1) is the determining factor for choosing the critical organ.
critical pathways	Those pathways which result in the most significant amount of exposure to radiation.
cumulative effects	The changes in the health of an individual(s) from the sum of all yearly exposures to radiation.
curie (Ci)	The curie is the common unit used for expressing the magnitude of radioactive decay in a sample containing radioactive material. Specifically, the curie is that amount of radioactivity equal to 3.7 x 1010 (37 billion) disintegrations per second. This unit does not give any indication of the radiological hazard associated with the disintegration.
defueling	Removal of all nuclear fuel from a nuclear-powered ship.
design earthquake	The maximum intensity earthquake that might occur along the nearest fault to a structure. Structures are built to withstand a design earthquake.
diffusion	The process of spreading out or scattering from regions of higher concentration to regions of lower concentration.
dispersion	The process of scattering or distributing over a large region.
dose	A general term which denotes the quality of radiation or energy absorbed; usually expressed in rems for doses to man.
dose commitment	The total radiation dose accrued by an individual over a specified period of time due to the exposure of the individual to radiation during a given interval of time. This includes the total time the radioactive material would reside in the body, if ingested or inhaled (usually expressed in rems).
dose commitment conversion factor	A factor which converts the quantity of radioactivity taken into the body to the dose to the individual (usually expressed in rems per curie).
dose equivalent	A quantity used to express all radiations on a common scale for calculating the effective absorbed dose. It is defined as the product of the absorbed dose and certain modifying factors and is expressed in rems.
dose rate	The amount of radiation dose delivered in a unit amount of time; for example, in rems per hour.
dose rate conversion factor	A factor which converts the exposure to a given radiation level to the dose that an individual could receive. It is usually expressed in rems per hour per curie per cubic meter (or square meter).
dredge spoil	Bottom sediments or materials that have been excavated from a waterway.
ecosystem	A community of plant and animal populations together with their physical environment. An organizational unit which can maintain its biological activities independent of other units.
element	A chemical substance that cannot be divided into simpler substances by chemical means. A substance whose atoms all have the same atomic number.
endangered species	A species or subspecies which is in danger of extinction throughout all or a significant portion of its range.
environmental consequences	Changes to the environment as a result of the effects of radiation or radioactive materials.
epidemiological study	A scientific study that deals with the incidence, distribution, and control of disease in a specified population.
exclusion area	An area where access would result in personnel exceeding radiation exposure limits in a very short time.
Expended Core Facility (ECF)	A large laboratory facility, located at the Naval Reactors Facility in Idaho, consisting of water pools and shielded cells used to receive, examine, and ship naval spent nuclear fuel and irradiated test specimen assemblies. Naval spent nuclear fuel is prepared at ECF for storage and shipment to the Idaho Chemical Processing Plant.
exposure, external	The subjecting of the outside of the body of an organism to ionizing radiation.
exposure, internal	The subjecting of the inside of the body of an organism to ionizing radiation.

exposure, occupational	The subjecting of an individual to ionizing radiation in the course of employment.
exposure, radiation	The subjecting of a material or organism to ionizing radiation.
fauna	Animals.
fissile	A material whose nucleus is capable of being split (fissioned) by neutrons of all energies.
fission	The splitting of a heavy nucleus into two approximately equal parts which is accompanied by the release of a relatively large amount of energy and generally one or more neutrons.
fission products	During operation of a nuclear reactor, heat is produced by the fission (splitting) of "heavy" atoms, such as uranium, plutonium, or thorium. The residue left after the splitting of these "heavy" atoms is a series of intermediate weight atoms generally termed "fission products." Because of the nature of the fission process, many fission products are unstable and, hence, radioactive.
floodplain	The lowlands which adjoin inland and coastal waters and relatively flat areas and floodprone areas of offshore islands which are covered with water from a 1-percent or greater chance flood in any given year.
floodplain/wetlands assessment	An evaluation which consists of a description of a proposed action, a discussion of its effects on the floodplain/wetlands, and a consideration of alternatives.
flora	Plants.
fuel	Fissionable material used or useable to produce energy in a nuclear reactor. It may also refer to a mixture, such as natural uranium, in which only part of the atoms are readily fissionable.
gamma ray	[Symbol - (gamma)] High-energy, short wavelength electromagnetic radiation. Gamma radiation frequently accompanies beta particle emissions. Gamma rays are very penetrating and are stopped most effectively by dense materials such as lead or uranium. They are essentially similar to x-rays but are usually more energetic and originate from the nucleus. Cobalt-60 is an example of a radionuclide that emits gamma rays.
geology	The study of the origin, history, materials, and structure of the earth.
geophysical survey	An examination of the condition, situation, or value of the earth using the physics of the earth including the fields of meteorology, hydrology, oceanography, seismology, volcanology, magnetism, radioactivity, and geology.
glaciation	The act of having been subjected to glaciers, extreme cold, and ice.
groundwater	Water that exists or flows beneath the earth's surface in the zone of saturation between saturated soil and rock.
half-life, biological	The time required for a biological system, such as an organ or tissue in an organism, to clear by natural (non-radioactive) processes, half the amount of a substance that has entered it.
half-life, radioactive	The time required for half of the atoms of a radioactive material to decay to another nuclear form.
hazardous wastes	Excess chemical material that is dangerous to human health.
health detriment	The sum of all fatal cancers, a fraction of the non-fatal cancers proportional to the severity of the cancer types, and all genetic defects.
health effect	The occurrence of a fatal cancer, a non-fatal cancer, or a genetic defect.
high-efficiency particulate filter	A ventilation system device that can separate a particle size of 0.3 micron from the air into a filter medium at an efficiency of at least 99.97 percent.
hydrology	The study of the properties, distribution, and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere.
incident-free operations	Routine, day-to-day operations without accidents or other unexpected or unusual occurrences. Synonymous and interchangeable with normal operations.
ion	An atom or molecule which has acquired an electrical charge by gaining or losing electrons.
ionizing radiation	Any radiation which displaces electrons from atoms or molecules, thereby producing ions. Examples include alpha, beta, and gamma radiation. Exposure to ionizing radiation may produce skin or tissue damage.
irradiate	To expose to radiation.
isotope	One of two or more nuclides which have the same number of protons but have different numbers of neutrons in their nuclei. Therefore, the isotopes of an element have the same atomic number but different atomic weights. Isotopes usually have very nearly the same chemical properties but somewhat different physical properties.
long-lived radioactivity	Radioactive nuclides which decay slowly, therefore having relatively long half-lives.
man-rem	A unit used to measure the radiation exposure to an entire group and to compare the effects of different amounts of radiation on groups of people. It is obtained by multiplying the average dose equivalent

	(measured in rems) to a given organ or tissue by the number of persons in the population of interest.
maximally exposed individual (MEI)	A theoretical individual who receives the highest radiation exposure from the facility or activity in question.
maximally exposed off-site individual (MOI)	A theoretical individual located at the point on the DOE site or shipyard boundary nearest to the facility or activity in question.
maximum individual	An individual who could consume items or occupy areas at rates which would be at a maximum for the population of interest.
maximum organ	The organ which receives or could receive the largest amount of exposure to radiation.
metric ton	[Abbreviation MT] A unit of mass which is equal to 1000 kilograms or approximately 2205 pounds.
microcurie	[Abbreviation -Ci] A unit of activity which is equal to one-millionth (1 x 10-6) of a curie.
mil	A unit of length which is equal to one-thousandth (1 x 10-3) of an inch.
millicurie	[Abbreviation mCi] A unit of activity which is equal to one-thousandth (1 x 10-3) of a curie.
millirem	[Abbreviation mrem] A special unit for measuring dose equivalents which is equal to one-thousandth (1 x 10-3) of a rem.
monitoring, environmental	The periodic or continuous determination of the amount of radioactivity or radioactive contamination present in a region.
natural background radiation exposure	The total amount of radiation from cosmic radiation emitted by the sun and the radiation emitted by natural minerals in the earth's crust. Typically, an average annual exposure of 100 mrem to the total body occurs from background radiation.
Naval Nuclear Propulsion Program	A joint program of the Department of Energy and the Department of the Navy which has as its objective the design and development of improved naval nuclear propulsion plants having high reliability, maximum simplicity, and optimum fuel life for installation in ships ranging in size from small submarines to large combatant surface ships. The program is frequently referred to as the Naval Reactors Program.
neutron	An uncharged particle with a mass slightly greater than that of a proton, found in the nucleus of every atom heavier than hydrogen. Neutrons sustain the fission chain reaction in a nuclear reactor.
nuclear disintegration	A spontaneous nuclear transformation which is characterized by the emission of particles and/or energy from the nucleus of an atom.
nuclear fuel	See fuel.
nuclear reactor	A device in which nuclear fission is initiated and controlled to produce heat which is then used to generate power.
nuclear reactor accident	An accident which results in release of fission products from the nuclear fuel.
nuclide	An atomic form of an element which is distinguished by its atomic number, atomic weight, and the energy state of its nucleus. These factors determine the other properties of the element, including its radioactivity.
organ	A group of tissues which together perform one or more definitive functions in a living body.
organism	Any living plant or animal.
overburden	Material overlying a deposit of useful geological materials.
particulate	Pertaining to a very small piece or part of a material.
pathway	The route or course along which radionuclides from defueled nuclear-powered ships could reach man.
percolate	To drain or seep through a material.
permeability	The quality or state of being able to diffuse or pass through a material.
pH	A measure of the relative acidity or alkalinity of a solution. A neutral solution has a pH of 7, acids have pH's less than 7, and bases have pH's greater than 7.
picocurie	[Abbreviation pCi] A unit of activity which is equal to one-trillionth (1 x 10-12) of a curie.
prototype plants	Land-based naval nuclear reactor plants that are typical of a first design for a naval warship and are used to test equipment and the nuclear fuel prior to use on a shipboard nuclear plant. The prototype plants are also used to train naval officers and enlisted personnel as propulsion plant operators with extensive watchstanding experience and a thorough knowledge of all propulsion plant systems and their operating requirements.
radiation	The emission and propagation of energy through matter or space by means of electromagnetic disturbances which display both wave-like and particle-like behavior. In this context, the "particles" are known as photons. The term has been extended to include streams of fast-moving particles such as alpha and beta particles, free neutrons, and cosmic radiations. Nuclear radiation is that which is emitted from atomic nuclei in various nuclear reactions and includes alpha, beta, and gamma radiation and neutrons.

radiation field	A region where radiation is present.
radiation level	The measured amount of radiation in a region.
radiation survey	The evaluation of an area or object with instruments to detect, identify, and quantify radioactive materials and radiation fields which may be present.
radiation worker	A person specially trained and tested in basic information regarding radiation, its effects, and radiological control techniques and practices.
radioactive contamination	The deposition of radioactive material in any place where it may harm persons, invalidate experiments, or make products or equipment unsuitable or unsafe for some specific use. The presence of unwanted radioactive matter.
radioactive decay	The process of spontaneous transformation of a radioactive nuclide to a different nuclide or different energy state of the same nuclide. Radioactive decay involves the emission of alpha particles, beta particles, or gamma rays from the nuclei of the atoms. If a radioactive nuclide is transformed to a stable nuclide, the process results in a decrease of the number of original radioactive atoms. Radioactive decay is also referred to as radioactive disintegration.
radioactive waste	Equipment and materials which are radioactive and for which there is no further use. Radioactive wastes are generally classified as high-level waste (those resulting from reprocessing reactor fuel or the used reactor fuel itself), as low-level waste, or as low-level waste containing transuranic elements or uranium-233.
radioactivity	The process of spontaneous decay or disintegration of an unstable nucleus of an atom; usually accompanied by the emission of ionizing radiation.
radioisotope	An unstable isotope of an element that decays or disintegrates spontaneously and emits radiation.
radiological consequences	The changes to the environment or the health of a person(s) as a result of the effects of radiation exposure or radioactive materials.
radionuclides	Atoms that exhibit radioactive properties. Standard practice for naming radionuclides is to use the name or atomic symbol of an element followed by its atomic weight (e.g., cobalt-60 or Co-60, a radionuclide of cobalt).
reactor vessel (or reactor pressure vessel)	A very strong, thick-walled steel structure which contains the nuclear fuel and cooling water under high pressure during reactor operations.
rem	A unit of measure used to indicate the amount of radiation exposure a person receives (an acronym for roentgen equivalent man).
risk	The product of the consequences of an event multiplied by the probability of that event.
river stage	The level of the surface of a river in relation to some reference elevation.
sediment	Particles of organic or inorganic origin that accumulate in loose form.
seismicity	The quality or state of shaking or vibrating caused by an earthquake.
shipping container	A specially designed large, stainless steel or lead-lined, steel-shelled cask that is transported in the vertical position on a well-type or depressed center railcar. The container is certified by the Department of Energy and the Department of Transportation for the shipment of naval spent nuclear fuel.
short-lived radioactivity	Radioactive nuclides which decay rapidly, therefore having relatively short half-lives.
socioeconomics	The welfare of human beings as related to the production, distribution, and consumption of goods and services.
special nuclear material	Materials containing nuclides such as plutonium-239, uranium-233, or uranium enriched to a higher percentage than normal in the uranium-235 isotope.
specific activity	The ratio between the amount of radioactive isotope present and the total amount of all other isotopes of that same element, both radioactive and stable. It is usually expressed in microcuries of radioisotope per gram of total element.
specimen	A small sample of material (fuel or non-fuel) inserted into a reactor for testing to characterize the material's performance. Test specimens may be constructed of plant materials, reactor structural materials, or fuel materials.
steam generator	The portion of the nuclear power plant where the heat from the primary system is transferred to the secondary system without physical contact between the water in the two systems.
survey meter	Any portable instrument which is used to detect radiation and is especially adapted for surveying or inspecting an area to establish the existence and amount of radioactive material present.
tectonic	Pertaining to or designating the rock structures which result from the deformation of the earth's crust.
threatened species	Any species or subspecies which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

topography	The detailed physical description of the surface of a region, including the relative elevations of features. The graphical representation of the physical configuration of a region on a map.
toxic	Relating to or caused by a toxin which is a poisonous substance that is a specific product of the metabolic activities of a living organism and is usually very unstable when introduced into human tissues.
tritium	A radioactive isotope of hydrogen with atoms that are three times the mass of ordinary light hydrogen atoms. Tritium is present in the reactor coolant as the result of neutron interaction with naturally occurring deuterium present in the water.
uranium	[Symbol U] A natural radioactive element with the atomic number 92 and, as found in natural ores, an average weight of approximately 238. The two principal natural isotopes are uranium-235 (0.7 percent of natural uranium) and uranium-238 (99.3 percent of natural uranium). Natural uranium also includes a minute amount of uranium-234.
vadose zone	The unsaturated region of soil located between the ground surface and water table.
water pools	Deep pools of water that are used to inspect and hold spent nuclear fuel modules. Storage racks are located below the water surface to support and position the fuel modules in place for handling and to prevent the formation of a critical mass.
water table	The upper surface boundary of an uncontrolled aquifer, below which groundwater occurs. It is usually defined by the levels at which water stands in wells that barely penetrate the aquifer.
watershed	The region which drains into a river, river system, or body of water.
wetlands	Those areas which are covered by water with a frequency sufficient to support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include swamps, marshes, bogs, and similar areas such as sloughs, potholes, wet meadows, river overflow, mudflats, and natural ponds.
x-rays	Penetrating electromagnetic radiations with wavelengths shorter than those of visible light. They are usually produced (as in medical diagnostic x-ray machines) by irradiating a metallic target with large numbers of high-energy electrons. In nuclear reactions, it is customary to refer to photons originating outside the nucleus as x-rays and those originating in the nucleus as gamma rays, even though they are the same.

ABBREVIATIONS AND ACRONYMS

AEA	Atomic Energy Act
AEC	Atomic Energy Commission
ANL-E	Argonne National Laboratory - East
ANL-W	Argonne National Laboratory - West
ATR	Advanced Test Reactor
Btu	British thermal unit
BWR	boiling water reactor
CAA	Clean Air Act
CDE	committed dose equivalent
CEDE	committed effective dose equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFA	central facilities area
CFR	Code of Federal Regulations
cfs	cubic feet per second
Ci	curies
cms	cubic meters per second
CNS	Charleston Naval Shipyard
CWRM	Commission on Water and Resource Management
DEP	Department of Environmental Protection
DOD	Department of Defense
DOE	Department of Energy
EB	Electric Boat Division of General Dynamics
ECF	Expended Core Facility
EDE	effective dose equivalent
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ERPG	Emergency Response Planning Guideline
FAA	Federal Aviation Administration
FMEF	Fuels and Materials Examination Facility
FWPCA	Federal Water Pollution Control Act
HEPA	high-efficiency particulate air
ICPP	Idaho Chemical Processing Plant
ICRP	International Commission on Radiological Protection
IDLH	immediately dangerous to life and health
INEL	Idaho National Engineering Laboratory

INEL-ECF	Idaho National Engineering Laboratory Expended Core Facility
INGL	Ingalls Shipbuilding
KAPL	Knolls Atomic Power Laboratory
KSO	Kesselring Site Operation
kv	kilovolts
kw	kilowatts
kwh	kilowatt hours
LET	linear energy transfer
MCW	maximally exposed collocated worker
MEI	maximally (or maximum) exposed individual
mg	milligram
mgd	million gallons of water per day
MINS	Mare Island Naval Shipyard
MMI	Modified Mercalli Index
MOI	maximally exposed off-site individual
mph	miles per hour
MVA	megavolt amperes
MW	megawatts
MWh	megawatt hours
NAAQS	National Ambient Air Quality Standards
NEA	Nuclear Energy Agency
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NNPP	Naval Nuclear Propulsion Program
NNS	Newport News Shipbuilding
NOAA	National Oceanic and Atmospheric Administration
NOR	Norfolk Naval Shipyard
NPA	nearest public access
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
NRF	Naval Reactors Facility
NTS	Nevada Test Site
NYSDEC	New York State Department of Environmental Conservation
OECD	Organization for Economic Co-operation and Development
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PAH	polycyclic (or polynuclear) aromatic hydrocarbons
PCB	polychlorinated biphenyl
pCi	picocuries
PHNS	Pearl Harbor Naval Shipyard
PHWMA	Pearl Harbor Water Management Area
PNS	Portsmouth Naval Shipyard
PSNS	Puget Sound Naval Shipyard
PWR	pressurized water reactor
RCRA	Resource Conservation and Recovery Act
RWMC	Radioactive Waste Management Complex
SAPS	Shippingport Atomic Power Station
SARA	Superfund Amendments and Reauthorization Act
SNF	spent nuclear fuel
SRS	Savannah River Site
SRS-ECF	Savannah River Site Expended Core Facility
TEDE	total effective dose equivalent
TI	transport index
TLV-TWA	threshold limit value, time-weighted average
TRA	test reactor area
USFWS	United States Fish and Wildlife Service
VOC	volatile organic compound
WIPP	waste isolation pilot plant
WSO	Windsor Site Operation

This draft may be exempt from disclosure
pursuant to the
Freedom of Information Act at 5 USC 552 (b.5)

APPENDIX E Spent Nuclear Fuel Management Programs At Other Generator/Storage Locations

Department of Energy
Programmatic
Spent Nuclear Fuel Management
and
Idaho National Engineering Laboratory
Environmental Restoration and
Waste Management Programs
Environmental Impact Statement
Preliminary Final
Volume 1
Appendix E
Spent Nuclear Fuel Management Programs
At Other Generator/Storage Locations
March 24, 1995
U.S. Department of Energy
Office of Environmental Management
Idaho Operations Office

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TABLES

1. INTRODUCTION

The U.S. Department of Energy (DOE) is performing a DOE-wide programmatic evaluation of spent nuclear fuel (SNF) management alternatives in order to determine the appropriate means of managing existing and projected quantities of SNF from now until the year 2035. At the same time, the DOE is performing a site-specific assessment of the Idaho National Engineering Laboratory (INEL) in order to determine how to manage environmental restoration, waste management, and SNF at the INEL. Sites currently involved with the management of major fractions of DOE SNF (i.e., the Hanford Site, Savannah River Site, and INEL), alternative sites being analyzed for management of SNF (Oak Ridge Reservation and Nevada Test Site), and sites involved with management of SNF from Naval Reactors are addressed in separate appendixes to this volume of the environmental impact statement (EIS).

This appendix addresses other DOE sites and locations which currently generate and manage small quantities of SNF. These facilities are presently storing and/or generating, in most cases, relatively small quantities of SNF which the DOE has taken title to, has possession of, or will take possession of at sometime in the future. These facilities, referred to in this document as "originating sites," include the following:

- DOE, University, and Other Research and Test Reactors

  The following DOE facilities are addressed in this appendix:

  Brookhaven National Laboratories
  - High Flux Beam Reactor
  - Brookhaven Medical Research Reactor

  Los Alamos National Laboratory
  - Omega West Reactor
  - Chemistry-Metallurgy Research Facility

  Sandia National Laboratories
  - Manzano Storage Structures
  - Annular Core Research Reactor
  - Sandia Pulse Reactor II and III and Critical Assembly
  - Hot Cell Facility
  - Special Nuclear Materials Storage Facility

  Argonne National Laboratory - East
  - Alpha-Gamma Hot Cell
  - Chicago Pile 5

  In addition, the DOE has title to SNF from university and other domestic research reactors. These facilities are identified and data provided on both the quantity of spent fuel in storage and estimates of the future generation rate of SNF at these facilities. However, rather than address each of these university and other research reactor facilities individually, representative facilities will be used when addressing specific topics related to facilities, the SNF, or projected environmental impacts associated with the various fuel management alternatives.

- Commercial Power Reactor Fuels

  The DOE has possession of 125 spent nuclear fuel assemblies and 20 complete or sectioned spent nuclear fuel rods from various nuclear power plants that were to be used to support DOE-sponsored research and development programs. This SNF is currently in storage at either the West Valley Demonstration Project in West Valley, New York, or the B&W Lynchburg Technology Center in Campbell County, Virginia.

  In addition, according to the terms of a three-party agreement between the Public Services Company of Colorado, General Atomics, and the Atomic Energy Commission, the DOE has a commitment to provide dry storage at the INEL for eight segments of Fort St. Vrain spent fuel (approximately 1,920 spent fuel elements). Three segments of this SNF have been shipped to the INEL; the other five are currently being stored at the Fort St. Vrain site.

  The DOE also has possession of other commercial SNF, including that from the Arkansas, Calvert Cliffs, Connecticut Yankee, Consolidated Edison, Cooper, Dresden, H. B. Robinson, Monticello, Oconee, Peach Bottom, Point Beach, Quad Cities, Saxton, Shippingport, Surry, and Three Mile Island reactors. These represent very small quantities of SNF and are currently stored at the Hanford Site, INEL, SRS, Naval

Reactor Facility at the INEL, or the ORR. This commercial SNF is addressed in the corresponding appendix for each of these sites and is not discussed in detail in this appendix.

Spent nuclear fuel from commercial power reactors which is currently at commercial reactor sites will fall under the purview of the DOE's Office of Civilian Radioactive Waste Management and is outside the scope of this EIS.

Although these facilities represent small sources of SNF, an evaluation has been conducted in order to consider the impacts at these originating sites along with the cumulative impacts of management of all DOE SNF.

Of the five SNF management alternatives being evaluated (Volume 1, Chapter 3), only the two alternatives that preclude the shipment of SNF (Alternative 1 - No Action and Alternative 2 - Decentralization) have a definable impact on the sites and facilities discussed in this appendix.

Several facilities generating SNF have limited storage capacities, and/or the facility license from the U.S. Nuclear Regulatory Commission (NRC) may limit the quantity of fuel permitted to be stored onsite. Implementation of the No Action Alternative could mean that some of the facilities with limited SNF storage capacity would have to shut down. The impact on some facilities would be the need to construct additional onsite SNF storage capacity in order to continue safe operation. Expansion of SNF storage capacity is only viable provided adequate space and adequate funding are available and expansion is approved through the NRC licensing process.

In the case of the West Valley Demonstration Project, the SNF is currently being stored in accordance with the applicable DOE Orders. Extended storage of SNF at this site would require construction of a concrete pad for a dry storage facility. However, the DOE has entered into an agreement with an agency of the State of New York to remove all SNF from the West Valley Demonstration Project. An extension to the schedule for removal of SNF has been requested by DOE and the agreement with the state is being renegotiated.

The other alternatives, which involve the shipment of the SNF from the site at which it is generated to one or more DOE SNF interim storage facilities, reflect the current mode of SNF management at the generating facilities. Even though the selection of a site where SNF may be transported and stored may be different than the current planning basis, shipment to a different location does not impact the facility or site at which the SNF is generated.

Section 2 of this appendix presents a description of SNF management at the originating sites, including an overview of the types and inventories for SNF in three major categories: DOE test and experimental reactors; domestic research reactors; and nuclear power reactor spent fuel. Section 3 presents summary descriptions of the potentially affected environments for the three categories, and Section 4 describes the environmental consequences of SNF management alternatives at these sites. Cumulative impacts are presented in Section 5, adverse impacts that cannot be avoided in Section 6, and irreversible and irretrievable commitments in Section 7.

2. SNF MANAGEMENT AT ORIGINATING SITES

2.1 Overview of SNF Types, Inventories, and Generation Rates

This appendix addresses the management of SNF at originating sites, defined as DOE test and experimental reactors, domestic research reactors, and certain nuclear power plant spent fuels now in storage. Specific discussions of the various sites are provided in following sections.

DOE experimental reactors and small-quantity storage: These reactors and SNF storage facilities are located on DOE-owned sites, such as Brookhaven National Laboratory, Los Alamos National Laboratory, and Sandia National Laboratories. These sites host a variety of research and development or production activities, which may include test or experimental reactors and storage of small quantities of SNF, in different areas of the site.

- Domestic research reactors: The greatest variations in site characteristics are those associated with research reactors. Most sites are at colleges or universities. However, a few of them are sited at government and industrial facilities.
- Nuclear power plant spent fuel: The SNF in this category is not located at currently operating nuclear reactor facilities. The facilities housing the subject SNF are located at the following sites: 1) the former West Valley fuel reprocessing site, 2) the shutdown Fort St. Vrain nuclear power plant site (currently undergoing decommissioning), and 3) a commercial research laboratory (B&W Lynchburg Technology Center) located on a large rural site. The DOE also has possession of other commercial SNF, including that from the Arkansas, Calvert Cliffs, Connecticut Yankee, Consolidated Edison, Cooper, Dresden H. B. Robinson, Monticello, Oconee, Peach Bottom, Point Beach, Quad Cities, Saxton, Shippingport, Surry, and Three Mile Island reactors. These represent very small quantities of SNF and are currently stored at the Hanford Site, INE~ SRS, Naval Reactors Facility at the INEl, or the ORR. This commercial SNF is addressed in the corresponding appendix for each of these sites and is not discussed further in this appendix.

The SNFs addressed in this appendix are of varying sizes and design configurations. In general, nuclear fuel consists of an assembly of structural components, such as plates or hollow rods, containing fissionable material. The fuel may be in the form of metal or a compound (e.g., oxide, carbide, nitride) and may vary in the degree of enrichment of the uranium -235 isotope. The structural materials may be aluminum, stainless steel, zirconium alloy, or other material such as ceramics. They form a barrier isolating the fuel (and fission products) from the reactor coolant or storage facility environment as well as providing structural support for maintaining the geometry of the fuel. The components are arranged into a specific geometric configuration determined by the type of reactor and desired performance. This assembly of fuel-bearing components is referred to as a "fuel element" (also referred to in the nuclear industry as a fuel assembly).

For each of the major facility categories, the following subsections provide details on the quantities of SNF currently in storage and the quantities of additional SNF expected to be produced by the end of the year 2035.

2.1.1 DOE Experimental Reactors and Small-Quantity Storage

The Brookhaven National Laboratory, Los Alamos National Laboratory, and Sandia National Laboratories use test and experimental reactors for research and for small-scale production of medical and other specific isotopes. In addition, small quantities of SNF are currently in storage at these sites as well as at Argonne National Laboratory - East. The amount of SNF generated by these facilities, the amount expected to be generated through the year 2035, and accommodations being undertaken at the present time to store the SNF located at these facilities are discussed in the following sections.

2.1.1.1 Brookhaven National Laboratory.

2.1.1.2.1 High Flux Seam Reactor-By mid-1995 there are projected to be 937

High Flux Beam Reactor elements (0.
241 MmlIM) in the reactor or in onsite wet storage. A total of 5,600 additional SNF elements (1.498 MThM) are predicted to be produced if the reactor continues operation through the year 2035 (Wichmann 1995a).

2.1.1.2.2 Brookhaven Medical Research Reactor-The Brookhaven Medical

Research Reactor is operating at the present time and has 36 elements (0.
0034 MTHM) in the rcactor or in onsite wet storage. Thirty-two additional SNF elements (0.0028 MTHM) are expected to be produced by the year 2035 (Wichmann 1995a).

2.1.1.2 Los Alamos National Laboratory.

2.1.1.2.1 Omega West Reactor-The Omega West Reactor has been permanently

shut down.
This reactor is being decommissioned. There are no elements in the reactor, and all of the 86 elements (0.014 MTHM) are in temporary dry storage at the Chemistry and Metallurgy Research Complex (Wichmann 1 995a).

Additional reactor sites and critical facilities that are part of the los Alamos National Laboratory are listed below. Each contains some radioactive and fissionable materials but does not routinely produce SNF (ANS 1988):

Big Ten Critical Assembly
- Fast Burst Reactor - GODWA
- Fast Burst Reactor - SKUA
- Flattop Critical Assembly
- General Purpose Critical Assembly - COMET
- General Purpose Critical Assembly - HONEYCOMB
- General Purpose Critical Assembly - PLANET
- General Purpose Critical Assembly - VENUS
- General Purpose Critical Assembly Machine
- Solution High Energy Burst Assembly

2.1.1.3 Sandla National Laboratories. The Sandia National Laboratory reactors operate

as needed on a low duty cycle, so the fission product inventories remain low and the fuel loading lasts for the life of the reactor, eliminating routine generation of spent fuel. Hence, except for a few broken plates that are in storage, the SNF at Sandia National Laboratories is still in use in the reactors (DOE 1993d).

The Sandia National Laboratories contain five SNF storage facilities: the Manzano Storage Structures, the Annular Core Research Reactor Facility, the Sandia Pulse Reactor Facility, the Hot Cell Facility, and the Special Nuclear Materials storage facility (DOE 1993b).

2.1.1.3.1 Manrano Storage Structures-The Manzano Storage Structures are

reinforced concrete bunkers located in the southeast portion of Kirtland Air Force Base. Until recently, when Sandia National Laboratories took responsibility for the site, the Manzano facilities were operated and maintained by the Department of Defense. The Sandia National Laboratories currently use four structures for dry storage of reactor-irradiated nuclear material (DOE 1993b). There is a total of 0.025 metric tons of heavy metal (MTHM) of SNF in storage at this facility (Wichmann 1995a).

2.1.1.3.2 Annular Core Research Reactor-The Annular Core Research Reactor is

a pool-type research reactor capable of steady-state, pulse, and tailored transient operation. The Annular Core Research Reactor facility includes the reactor pool, one safe, and eight dry floor storage vaults, all located in the high-bay of Building 6588. The eight storage vaults on the high-bay floor are used to securely store irradiated experiments containing a variety of nuclear materials, but principally U-235. Materials from only three experiments containing reactor irradiated nuclear materials are stored at the Annular Core Research Reactor (DOE 1993b). There are a total of 438 elements plus uranium from three experiments (for a total of 0.04MTHM) in use or storage at these facilities (Wichmann 1995a).

In addition, DOE is considering using the Annular Core Research Reactor for production of molybdenum-99. If the molybdenum -99 production mission is assigned to the Annular Core Research Reactor, the current reactor fuel would likely be removed and would need to be stored at the start of, or within a few years of starting, operation (SNL 1994).

2.1.1.3.3 Sandia Pulse Reactor Hand HI, and Critical Assembly- Three reactors

are in operation at the Sandia Pulse Reactor facility: Sandia Pulse Reactor II and Sandia Pulse Reactor III are unmoderated, fast-burst reactors capable of pulsed and steady-state operation. The Critical Assembly is a small, water-moderated reactor used to perform measurements of key reactor parameters to benchmark the computer calculations and thereby refine the designs for a planned space propulsion reactor. The yard storage holes are 19 stainless-steel types located in a corner of the Sandia Pulse Reactor compound. These tubes are surrounded by a high-density concrete monolith. The yard holes are used to securely store irradiated experiments containing a variety of nuclear materials, but principally U-235. All of the materials remain in their own containers, some of which consist of double containment. At the Special Nuclear Material dry storage facility, Sandia National Laboratories stores previously failed fuel elements from Sandia Pulse Reactor II and elements from experiments that have been exposed to short irradiation periods (DOE 1993b). There are a total of 43 elements (with a total of 0.37 MTHM) of SNF in use or storage at these facilities (Wichmann 1995a).

Future plans include bringing on-line an additional pulse reactor named Sandia Pulse Reactor IlIM. With this new reactor, a total of three pulse reactors would be located at Sandia National Laboratories' Technical Area V.

2.1.1.3.4 Hot Cell Facilty-The Hot Cell Facility at Sandia National Laboratories is

a nonreactor nuclear facility housed in Building 6580 in Technical Area V. Research programs at Sandia National Laboratories--material studies, fuel studies, and safety studies.-require that experiments containing radioactive materials be assembled and/or disassembled, samples prepared, and microscopic and chemical analyses performed. The principal storage facility for the Hot Cell Facility is Room 108, which is a heavily shielded room used previously as a preparation room next to the irradiation room of the Sandia Engineering Reactor, which has been defueled. There are a series of 13 storage holes under the Hot Cell Facility Monorail that are available to store irradiated material coming into or out of the Hot Cell Facility. Only one of the holes is currently in use. The other areas of the Hot Cell Facility are used for storing minor amounts of material (DOE 1993b) There is a total of 0.009 MTHM of SNF in storage at this facility (Wichmann 1995a).

2.1.1.4 Argonne National Laboratory - East. The Alpha-Gamma Hot Cell Facility,

operated by the Materials Science Division, consists of a concrete-shielded, low-flow inert-atmosphere complex that was designed for the examination of irradiated plutonium fuel assemblies and related hardware (DOE 1993d). There are a total of four units of Experimental Breeder Reactor fuel, one canister containing remnants of commercial SNF, and 16 SNF elements from Oak Ridge (For a total of 0.081 MTHM) in storage (Wichmann 1995a).

The Chicago Pile 5 Building houses a heavy-water, moderated reactor whose fuel has been removed and shipped offsite. Currently, the Chicago Pile S is in the process of being decontaminated and decommissioned and contains only two highly enriched uranium target (i.e., converter) elements (DOE 1993d).

2.1.2 Domestic Licensed Research Reactors

Table 2.1-1 identifies 57 non-DOE facilities representing domestic, licensed, small generators of SNF (NRC 1993a; ANS 1988). They include training, research, and test reactors at universities, commercial establishments, and several government installations; all but one (McClellan Air Force Base) have been licensed by the NRC. Although they are not DOE Facilities, DOE has title to the SNF and has the responsibility for interim storage and ultimate disposition.

In order to assess their SNF management capabilities, these 57 facilities have been identified as belonging to one of three categories. These categories identify the key characteristics of a facility relevant to the assessment of DOE-postulated SNF alternatives. The three categories are:

Category 1 - Facilities that have limited onsite storage capacity compared to the amount of SNF projected to be generated at their facility by the year 2035
Category 2 - Facilities that do not routinely generate additional SNF
Category 3 - Facilities that no longer possess SNF onsite.

The category for each facility is identified in Table 2.1-1.

Table 2.1-1. Domestic non-DOE research reactors.

Licensee location	Reactor type	NRC Docket no.	Category
Aerotest San Ramon, CA	TRIGA (Indus)	50-228	2
Arkansas Tech Univ. Russellville, AR	TRIGA	50-606	2
Armed Forces Radiobiology Research Institute (AFRRI) Bethesda, MD	TRIGA	50-170	2
Brigham Young Univ. Provo, UT	L-77	50-262	3
Catholic University Washington, DC	AGN-201	50-77	3
Cintichem, Inc. Tuxedo, NY	Pool	50-54	3
Cornell University Ithaca, NY	TRIGA	50-157	2
Cornell University Ithaca, NY	ZPR	50-97	2
Dow Chemical Company Midland, MI	TRIGA	50-264	2
General Atomics San Diego, CA	TRIGA Mark I	50-89	2
General Atomics San Diego, CA	TRIGA Mark F	50-163	2
General Electric Co. Pleasanton, CA	NTR	50-73	1
Georgia Institute of Technology Atlanta, GA	Research HW	50-160	2
Idaho State University Pocatello, ID	AGN-201	50-284	2
Iowa State University Ames, IA	MTR-10 Pool	50-116	2

Kansas State University Manhattan, KS	TRIGA	50-188	1

Licensee location	Reactor type	NRC Docket no.	Category
McClellan Air Force Base McClellan, CA	SNRS	None	2
Manhattan College Riverdale, NY	Tank-ZPR	50-199	2
Massachusetts Institute Research of Technology Cambridge, MA	HW	50-20	1
N.S. Savannah Mount Pleasant, SC	PWR	50-238	3
NASA Plum Brook Sandusky, OH	NASA Tr. Tank	50-185	3
National Institute of Standards and Technology (NIST) Gaithersburg, MD	Test	50-184	1
North Carolina State U. Raleigh, NC	Pulstar	50-297	2
Ohio State University Columbus, OH	Pool	50-150	2
Oregon State University Corvallis, OR	TRIGA	50-243	2
Penn State University University Park, PA	TRIGA	50-5	2
Purdue University West Lafayette, IN	Lockheed	50-182	2
Reed College Portland, OR	TRIGA	50-288	2
Rensselaer Polytechnic Institute Troy, NY	Critical Assembly	50-225	2
Rhode Island Atomic Energy Commission Narragansett, RI	Pool	50-193	1
State Univ. of New York Buffalo Buffalo, NY	Pulstar	50-57	1
Texas A&M University College Station, TX	AGN-201	50-59	2
Texas A&M University College Station, TX	TRIGA	50-128	1
U.S. Geological Survey Denver, CO	TRIGA	50-274	1
University of Arizona Tucson, AZ	TRIGA	50-113	2
University of California at Berkeley Berkeley, CA	TRIGA	50-224	3
University of California at Irvine Irvine, CA	TRIGA	50-326	2
University of California at Los Angeles Los Angeles, CA	Educator	50-142	3
University of Florida Gainesville, FL	Argonaut	50-83	2
University of Illinois Urbana, IL	LOPRA	50-356	1
University of Kansas Lawrence, KS	Lockheed	50-148	3
University of Maryland College Park, MD	TRIGA	50-166	2
University of Mass. at Lowell Lowell, MA	GE Pool	50-223	2
University of Michigan Ann Arbor, MI	Pool	50-2	1
University of Missouri Columbia Columbia, MO	Tank	50-186	1
University of Missouri Rolla Rolla, MO	Pool	50-123	2
University of New Mexico Albuquerque, NM	AGN-201	50-252	2
University of Texas Austin, TX	TRIGA-Mark II	50-602	2

University of Utah Salt Lake City, UT	TRIGA	50-407	2
University of Virginia Charlottesville, VA	Pool	50-62	1
University of Washington Seattle, WA	Argonaut	50-139	3
University of Wisconsin Madison, WI	TRIGA	50-156	2
Veterans Admin. Medical Center Omaha, NE	TRIGA	50-131	2
Washington State U. Pullman, WA	TRIGA	50-27	2
Watertown Army Materials Research Reactor Watertown, MA	Pool	50-47	3
Westinghouse Zion Training Reactor Pittsburgh, PA	W Tank	50-22	3
Worcester Polytechnic Institute Worcester, MA	Pool	50-134	2

2.1.2.1 Reactors with Limited Storage Capacity. The sites in Category I have limited

storage capacity when compared to the amount of SNF that is projected to be generated by 2035. Table 2.1-2 lists the projected inventory as of June 1, 1995 with the corresponding MTHM at **each of the Category 1 sites.** Assuming continuing operation of each reactor, the projected amount of additional SNF that would be generated through 2035 is also provided in Table 2.1-2.

To reduce the risk of theft or diversion of highly enriched uranium fuel and the consequences to public health, safety, and the environment from such theft or diversion, the NRC has imposed limitations on the use of highly enriched uranium fuel in domestic nonpower reactors. Unless the NRC has determined that the nonpower reactor has a unique purpose requiring the use of high enriched uranium fuel, each licensee will replace all highly enriched uranium fuel in its possession with available low enriched uranium fuel acceptable to the Commission. If federal government funding for conversion is not available, the conversion from high enriched uranium fuel to low enriched uranium fuel may be deferred on an annual basis. A number of domestic research reactors are in the process of converting from highly enriched uranium fuel to low enriched uranium fuel.

2.1.2.2 Reactors with Sufficient Storage Capacity. Licensed domestic research reactor

sites with sufficient SNF storage capacity are listed in Table 2.1-3. These Category 2 sites include operating facilities with low fuel burnup rates, where the amount of SNF generated is not expected to exceed the current onsite storage capacity. Some Category 2 sites are also converting from highly enriched uranium fuel to low enriched uranium fuel but have sufficient capacity to store this additional SNF onsite.

The projected inventory at each reactor site as of June 1, 1995 and the corresponding MTHM are presented in Table 2.1-3. The amount of SNF that is projected to be generated through the year 2035 is also listed in Table 2.1-3.

2.1.2.3 Reactors without SNF Onsite. The licensed domestic research reactors that are

no longer operating and have shipped all SNF offsite are identified as Category 3 in Table 2.1-1. These sites either have been decommissioned or are in the process of decommissioning. Some of the facilities have been decontaminated, although they may not have been completely dismantled.

Table 2.1-2. Category 1 projected SNF inventories.

Licensee location	Inventory as of June 1, 1995		Future increases through 2035	
	Elements	MTHM	Elements	MTHM
Kansas State University Manhattan, KS	107	0.020	140	0.027
Massachusetts Institute of Technology Cambridge, MA	66	0.021	480	0.150
National Institute of Standards and	186	0.04	1,160	0.300

Technology Gaithersburg, MD				
Rhode Island Atomic Energy Commission Narragansett, RI	57	0.030	160	0.222
State University of New York - Buffalo Buffalo, NY	25	0.493	5	0.100
Texas A&M (TRIGA) College Station, TX	186	0.030	378	0.060
U.S. Geological Survey Denver, CO	161	0.032	39	0.010
University of Illinois Urbana, IL	198	0.037	313	0.59
University of Michigan Ann Arbor, MI	103	0.072	480	0.400
University of Missouri Columbia, MO	82	0.055	1,040	0.700
University of Virginia Charlottesville, VA	65	0.066	60	0.210

a. Source: Wichmann 1995a.

Note: Projected inventory as of June 1, 1995 is 0.896 MTHM.
Projected additional SNF generated through 2035 is 2.769 MTHM.

Table 2.1-3. Category 2 projected SNF inventories.

Licensee location	Inventory as of June 1, 1995		Future increase through 2035	
	Elements	MTHM	Elements	MTHM
Aerotest San Ramon, CA	91	0.015	0	0
Arkansas Tech. Univ. Russellville, AR	0	0	0	0
Armed Forces Radiobiology Research Institute Bethesda, MD	95	0.018	0	0
Cornell University (TRIGA) Ithaca, NY	123	0.023	770	0.143
Cornell University (ZPR) Ithaca, NY	814[d]	1.7[d]	0	0
Dow Chemical Company Midland, MI	78	0.014	0	0
General Atomics[c] San Diego, CA	263	0.058	20	0.016
GE Nuclear Test Reactor Plesanton, CA	8	0.008	0	0
Georgia Institute of Technology Atlanta, GA	50	0.030	120	0.107
Idaho State University Pocatello, ID	9[d]	0.011[d]	0	0
Iowa State University Ames, IA	27	0.024	0	0
McClellan Air Force Base McClellan, CA	90	0.015	0	0
Manhattan College Riverdale, NY	17[d]	0.019[d]	0	0
North Carolina State U.	34	0.428	25	0.315

Licensee location	Inventory as of June 1, 1995		Future increase through 2035	
	Elements	MTHM	Elements	MTHM
Raleigh, NC				
Ohio State University Columbus, OH	24 and 638b	0.021	0	0
Oregon State University Corvallis, OR	96	0.017	96	0.060
Pennsylvania State Univ. University Park, PA	175	0.041	40	0.009
Purdue University West Lafayette, IN	13	0.002	13	0.063
Reed College Portland, OR	67	0.013	0	0
Rensselaer Polytechnic Instituteb Troy, NY	597d	0.388d	0	0
Texas A&M - AGN-201 College Station, TX	9	0.011	0	0
University of Arizona Tucson, AZ	97	0.081	8	0.0015
University of California Irvine Irvine, CA	113	0.021	0	0
University of Florida Gainesville, FL	23	0.04	22	0.172
University of Maryland College Park, MD	93	0.016	93	0.016
University of Mass. Lowell Lowell, MA	26	0.004	26	0.100
University of Missouri Rolla, MO	56	0.269	0	0
University of New Mexico Albuquerque, NM	9d	0.004d	0	0
University of Texas Austin, TX	154	0.029	0	0
University of Utah Salt Lake City, UT	139	0.026	0	0
University of Wisconsin Madison, WI	228	0.039	0	0
Veterans Admin. Medical Center Omaha, NE	56	0.001	0	0
Washington State Univ. Pullman, WA	215	0.037	112	0.051
Worcester Polytechnic Institute Worcester, MA	27e	0.022	0	0

a. Source: Wichmann 1995a and Wichmann 1995b.

b. Fuel pins, not reactor assemblies.

c. Reactor scheduled to shut down in 1998.

d. Contact-handled fuel/targets (i.e., with radiation levels low enough to permit handling without shielding or remote operations), even though slightly irradiated, are not included as SNF.

Note: The projected inventory as of June 1, 1995 is expected to be 1.323 MTHM and the approximate total for the additional SNF projected to be generated through 2035 is 1.054 MTHM. Numbers may not sum due to rounding.

The SNF that originated at these sites has either been reprocessed or is stored and accounted for at DOE storage facilities.

2.1.3 Nuclear Power Plant Spent Nuclear Fuel

This subsection addresses spent nuclear power plant fuel that DOE has possession of or will take possession of sometime in the future. Currently this fuel is in storage at one of three sites: the West Valley Demonstration Project, the Fort St. Vrain nuclear power plant site, and the

B&W Lynchburg Technology Center in Lynchburg, Virginia. In all cases, no new additional SNF is being or will be added to existing SNF inventories.

2.1.3.1 West Valley Demonstration Project. The West Valley Demonstration~ Project is

located on the site of the first U.S. commercial nuclear fuel reprocessing plant, which was operated by Nuclear Fuel Services, Inc., until 1972 (WVNS 1994).

Nuclear Fuel Services, Inc., shut down the reprocessing facility in 1972 in order to implement modifications for the purpose of increasing the facility's capacity. From 1973 to 1975 Nuclear Fuel Services, Inc., continued to accept a total of 750 SNF elements. However, in 1976, it withdrew from the reprocessing business (WVNS 1994).

In 1980 Congress enacted Public Law 96-368, the West Valley Demonstration Project Act. The act directed the DOE to develop and demonstrate the technology for solidifying high-level waste in storage at the West Valley Demonstration Project so that this waste would be suitable for transportation to and long-term disposal in a federal repository (wvNS 1994).

The owners of the 750 SNF elements still in storage at the West Valley facility fuel storage pool were informed in 1981 that they would have to take back their SNF. By 1986, 625 of the elements had been returned to their respective owners; then, however, DOE took possession of the remaining 125 SNF elements (26.65 MTHM) under an agreement with Nuclear Fuel Services, Inc. The DOE was to use these 125 elements to demonstrate the safe transportation and long-term storage of SNF in a dual-purpose cask. These 125 SNF elements are included in this EIS (Wichmann 1995a).

2.1.3.2 Fon St. Vrain. Fort St. Vrain, a 330 MWe (Megawatt electric) high-temperature

gas-cooled reactor power plant, went into operation in January 1979 and teriminated commercial operation in August 1989. It is currently undergoing decommissioning (FSV 1990a; NRC 1991a)

Prior to August 1989 a three-party agreement was reached between the Public Services Company of Colorado (the owner of Fort St. Vrain), General Atomics (the reactor developer), and the DOE that called for the DOE to take possession of eight segments of approximately 240 SNF elements each of SNF from the Fort St. Vrain for dry storage at the INEL. SNF from the Fort St. Vrain had been shipped to the INEL when a court action was initiated by the state of Idaho to stop any additional shipment of SNF to INEL.

In an effort to facilitate the continued decommissioning of the Fort St. Vrain station, the Public Services Company of Colorado has decided to store the Fort St. Vrain's SNF in a modular vault dry storage system, which is a reinforced concrete and sheathed steel frame building located on the Fort St. Vrain site immediately adjacent to but outside the fence around the Fort St. Vrain site. The modular vault dry storage system, designed to house 1,482 high-temperature, gas-cooled reactor SNF elements, 6 neutron source elements, and 37 keyed top reflector elements, became operational in late 1991 (FSV 1990a). There are 1,464 elements (16 MTHM) currently in storage in the modular vault dry storage system (Wichmann 1995a).

2.1.3.3 B&W Lynchburg. The B&W facility in Lynchburg, Virginia, is engaged in

research and development on uranium fuels and the overall fuel cycle, and in the examination and testing of irradiated fuels (NRC 1987).

B&W Lynchburg currently has in storage at its facility 0.044 MTHM of SNF stored in 15 cannisters (Wichmann 1995a) consisting of 3 full.length fuel rods, 17 sectioned fuel rods, and a small quantity of fuel debris from Three Mile Island 2. All of this SNF material is in the possession of the DOE and was provided to B&W under a DOE contract for Fuel Performance Improvements Programs. None of the activities ongoing at B&W Lynchburg could result in the generation of additional SNF for which the DOE has responsibility, since the facility's three reactors have been decommissioned (Wright 1993; ANS 1988).

2.2 Spent Nuclear Fuel Management Program Plans and Alternatives

The plans for management of SNF at originating sites, including generating and storage sites, or facilities generating small annual quantities of SNF, were determined by conducting a survey of the NRC licensees and others operating these sites. These plans, as they are projected to be affected by the alternatives being assessed in this EIS, are presented in this section.

Availability of onsite SNF storage capacity is the primary consequence of DOE SNF management decisions for all originating sites. Of the five DOE SNF management alternatives, only Alternative 1 (No Action - no SNF transportation) may not have been addressed under the NRC licensing process for an individual SNF originating site. DOE management plans for the alternatives which involve SNF transportation- would not affect the originating sites. The. management plans at the DOE facilities to which the SNF may be shipped are addressed in the sections of this EIS dealing with those DOE facilities. The alternate plans with regard to transportation are analyzed in Appendix I to Volume 1. Accordingly, the next few subsections will focus primarily on the No Action Alternative and describe general information on SNF produced at the originating sites, including non-DOE facilities storing SNF.

2.2.1 No Action

The No Action Alternative is intended to evaluate the impact of storage of SNF at the current storage and originating sites. This means that all facilities which are generating or storing SNF and intend to ship SNF to a DOE facility would maintain their SNF onsite. If the SNF-originating site has adequate storage capacity, operations at the site would continue without change of plans. If SNF storage capacity is inadequate, new plans, including expansion of storage capacity or decreasing the rate of fuel burn-up, would have to be considered. Possible SNF management plans are discussed more specifically in the following subsections.

Of the total of approximately 2,700 MThM of SNF estimated as the total DOE inventory by 2035, approximately 51 MTHM of SNF is associated with the facilities addressed in this appendix (Wichmann 1995a).

2.2.1.1 DOE Experimental Reactors and Small Quantity Storage. There is insufficient

onsite storage capacity at the High Flux Beam Reactor at Brookhaven National Laboratory to store all of the SNF projected to be generated through the year 2035. If SNF shipments are no made to another DOE storage facility, at the current rate of generation the remaining onsite storage space would be depleted in January 1996. There is a plan to install a storage rack in the existing wet storage facility that would add space for 162 elements. Even with this rack, storage space would be depleted in 1998. If SNF could not be shipped by that time, the arrangement of existing racks could be modified to provide additional space. There are no plans to shut down the reactor in the near future (Carelli 1993).

2.2.1.2 Domestic Research Reactors. Based on current projections, the onsite storage

capacity of 11 of the 45 domestic research reactors would be exhausted before the year 2035 if the No Action Alternative were to be implemented. All 11 of these facilities have been identified as Category 1.

Several of the facilities in Category 1 have indicated that they would consider various options of increasing storage capacity if the No Action Alternative were to be implemented. Five would consider reracking, one would consider expanding dry storage within the reactor building, three would consider expanding wet storage within the reactor building, and one would consider adding 200 square feet (18.6 square meters) of wet storage area outside the reactor building.

Any previously planned expansion of onsite SNF storage capacity at individual odginating facilities is addressed in site-specific NRC environmental assessments and thus is not considered to be a consequence of the proposed actions under this ElS. The facilities that are already planning to expand their SNF storage capacity include the Massachusetts Institute of Technology and the National Institute of Standards and Technology.

At one of these facilities the expanded storage capacity is projected to be adequate through the year 2005. However, without SNF transportation through the year 2035, none of the facilities would have adequate storage capacity. One of the facilities in Category 1 has offloaded its highly enriched uranium fuel and would consider reracking but might elect to shut down in 2001 because of a lack of wet storage capacity (Jentz 1993).

All 34 facilities identified as Category 2 have sufficient SNF storage capacity onsite to accommodate any of the DOE SNF alternatives. Two facilities may elect to shut down before the year 2005: one because it may not renew its license; the other because, without transferring SNF offsite, it might not meet licensing limits on possession of uranium-235 after conversion from highly enriched uranium fuel to low enriched uranium fuel. One facility, which expects to convert from highly enriched uranium fuel to low enriched uranium fuel, might elect to shut down in the year 2005 if no offsite transportation were available, unless it can expand its SNF wet storage capacity. A few facilities have indicated that they will appeal the NRC-required conversion of highly enriched uranium fuel to low enriched uranium fuel if no oflsite transportation is allowed.

Although several Category 2 facilities can operate practically indefinitely without refueling, it is questionable how many of them would operate as planned if there were no SNF transportation through the year 2035. Many research reactors operate with variable core loadings, storing, and reusing partially depleted fuel elements as well as adding new fuel to the reactor (Jentz 1993).

2.2.1.3 Nuclear Power Plant Spent Nuclear Fuel. The No Action Alternative

necessitating extended interim onsite storage of SNF would require a revision of the SNF management program at the West Valley Demonstration Project. The need to revise this program is a result of the following (DOE 1993b):

The West Valley fuel pool is almost 30 years old and does not meet current DOE design criteria.

The pool is single-walled, unlined, and lacks the capability for leak detection, thus presenting the potential for an undetected release to the environment.

Continued storage of fuel onsite would interfere with and for some areas prevent the ongoing decontamination and decommissioning activities at the West Valley Demonstration Project facility from proceeding as planned.

The management of SNF at the West Valley Demonstration Project is to continue the use of the existing spent fuel pool with no modifications.

Loss of access to the INEL for storage of its SNF has already resulted in the construction o new onsite SNF storage at Fort St. Vrain. However, under this alternative Public Service Company of Colorado would not achieve its goal of becoming free of radioactive materials by 1998 under this option.

Adequate storage capacity exists and the storage facilities are in adequate condition at the B&W Lynchburg Technology Center (DOE 1993b).

2.2.2 Decentralization

Alternative 2, Decentralization, is similar to the No Action Alternative except that limited offsite shipments are permitted as required to allow continued operation of the given facility. Decentralization is not expected to impose additional requirements for storing SNF at the facilities included in this appendix above those already identified under the No Action Alternative. Planning at the sites receiving SNF shipments that would be allowed under this alternative is addressed in Appendixes A, B, and C. Intersite transportation impacts are analyzed in Appendix I to Volume 1.

2.2.2.1 DOE Experimental Reactors and Smell Ouantity &orage. Compared to the

restrictions imposed under the No Action Alternative, Decentralization does not change the management plans at these DOE experimental reactors and small.quantity storage facilities.

2.2.2.2 Domestic Research Reactors. The Decentralization Alternative is similar to the

No Action Alternative, except that limited offsite shipments are permitted as required to allow continued operation of the given facility. Under this alternative, the domestic research reactors are allowed to return to DOE any SNF in excess of their current onsite storage capacity. Additional storage capacity would be not be required at these originating facilities. Therefore, decentralization does not affect existing SNF management plans at university research reactors or other facilities in the domestic research reactor group, except for possible rerouting of SNF shipments to INEL or Savannah River Site.

2.2.2.3 Nuclear Power Plant Spent Nuclear Fuel. The Decentralization Alternative is

similar to the No Action Alternative, except that limited offsite shipments are permitted as required to allow continued operation of the given facility. The three facilities being addressed in this subsection are only storing SNF and do not generate additional SNF. Because SNF would not be shipped offsite, SNF remaining at the site could interfere with the planned decontamination and decommissioning operations at West Valley Demonstration Project. Under this option, Public Service Company of Colorado would not achieve its goal of becoming free of radioactive material by 1998.

2.2.3 1992/1993 Planning Basis

Alternative 3, 1992/1993 Planning Basis, would not be expected to change any existing SNF management plans at the sites included in this appendix. Alternative 3 would permit the timely shipment of SNF from the originating sites to DOE interim storage facilities at INEL or Savannah River Site. Planning at these SNF-receiving sites is addressed in Appendixes A, B, and C. Interstate transportation impacts are analyzed in Appendix I to Volume 1.

2.2.3.1 DOE Experimental Reactors and Small Quantity Storage. Implementation of

this alternative could require a transition period of several years. Therefore, limited onsite construction of temporary SNF storage facilities or acquisition of SNF transportation containers, suitable for use as temporary dry storage containers, may be necessary until shipment to a D9E interim storage site(s) is accomplished.

2.2.3.2 Domestic Research Reactors, Alternative 3 does not affect the existing SNF

management plans at domestic research reactor facilities. Management of SNF at these reactors would continue to follow the same plans as in the past.

2.2.3.3 Nuclear Power Plant Spent Nuclear FueL Under Alternative 3, DOE plans to

ship the SNF currently in storage at the West Valley Demonstration Project to INEL Test Area North for storage. Implementation of this alternative would therefore preclude the need for any additional action at the West Valley Demonstration Project related to providing a new onsite SNF storage facility.

If Public Service Company of Colorado shipped the remaining fuel segments, the Fort St. Vrain Site would be free of radioactive materials by 1998.

This alternative would have no impact on the management of the SNF material in storage at the B&W Lynchburg Technology Center.

2.2.4 Regionalization

Alternative 4, Regionalization, would not be expected to change any existing SNF management plans at the sites included in this appendix, Alternative 4 would permit the shipment of SNF from the originating sites to regional DOE interim storage facilities. Planning at the SNF-recieving sites is addressed in Appendixes A, B, C, and F. Intersite transportation impacts are analyzed in Appendix I to Volume 1.

2.2.4.1 DOE Experimental Reactors and Small Quantity Storage. Implementation of

this alternative could require a transition period of several years. Therefore, limited onsite construction of temporary SNF storage facilities or acquisition of SNF transportation containers, suitable for use as temporary dry storage containers, may be necessary until shipment to a DOE interim storage site(s) is accomplished.

2.2.4.2 Domestic Research Reactors. Regionalization does not affect the existing SNF

management plans at domestic research reactor facilities, except for possible rerouting of SNF shipments.

2.2.4.3 Nuclear Power Plant Spent Nuclear Fuel. The Regionalization Alternative for

SNF addressed in this appendix is the same as the 1992/1993 Planning Basis Alternative except that the SNF would be sent to other locations. With the exception of INEL, facilities are not presently available for SNF storage at receiving sites considered under regionalization for SNF from West Valley Demonstration Project and Fort St. Vrain. The SNF would remain in storage at West Valley Demonstration Project and Fort St. Vrain until facilities are available for receipt at the selected regional SNF management sites.

2.2.5 Centralization

Alternative 5, Centralization, would not be expected to change any existing SNF management plans at the sites included in this appendix. Alternative 5 would permit the shipment of SNF from the originating sites to centralized DOE interim storage facilities.

planning at the SNF-receiving sites is addressed in Appendixes A, B, C, and F. Intersite transportation plans are analyzed in Appendix I to Volume 1.

2.2.5.1 DOE Expedmental Reactors and Small Ouantity Storage. Implementation of

this alternative could require a transition period of several years. Therefore, limited onsite construction of temporary SNF storage facilities or acquisition of SNF transportation containers, suitable for use as temporary dry storage containers, may be necessary until shipment to a DOE interim storage site(s) is accomplished.

2.2.5.2 Domestic Research Reactors. Centralization does not affect the existing SNF

management plans of domestic research reactor facilities except for rerouting of SNF shipments.

2.2.5.3 Nuclear Power Plant Spent Nuclear Fuel. The Centralization Alternative for

SNF being addressed in this appendix is described as being the same as the 1992/1993 Planning Basis Alternative except that the SNF would be sent to other locations. With the exception of INEL, facilities are not presently available for SNF storage at receiving sites considered under centralization for SNF from West Valley Demonstration Project and Fort St. Vrain. The SNF would remain in storage at West Valley Demonstration Project and Fort St. Vrain until facilities are available for receipt of the SNF at the selected central SNF management site.

3. AFFECTED ENVIRONMENTS

Descriptions of those facilities generating and/or storing small quantities of spent nuclear fuel for which DOE has accepted responsibility are presented in this section. The following subsections present environmental information for each of the three categories of originating sites: DOE Test and Experimental Reactors, Domestic Research Reactors, and Nuclear Power Plant Spent Nuclear Fuel Storage Sites.

The wide variety of facilities and installations included in this category precludes the definition of their affected environments in a consistent and uniform manner. The information available in existing facility documents used as the bases for this analysis varies widely with the nature of the installation and the requirements of the overseeing or regulatory agencies.

3.1 DOE Experimental Reactors and Small-Quantity Storage

The DOE experimental reactors and small-quantity SNF storage facilities included in this category are located at the Brookhaven National Laboratory, Los Alamos National Laboratory, Sandia National Laboratory, and Argonne National Laboratory - East. The facilities, sites, and their environments are described in this section. Only those DOE sites at which spent nuclear fuel is currently generated and/or stored are discussed. Information on environmental factors that are not uniformly available in existing National Environmental Policy Act documentation for all four sites (including aesthetic and scenic resources, noise, traffic and transportation, and utilities and energy) is not provided in this document.

3.1.1 Brookhaven National Laboratory

There are two reactors at the Brookhaven National Laboratory which generate SNF potentially affected by actions analyzed in this EIS: the 60 MW High Flux Beam Reactor and the 5 MW Brookhaven Medical Research Reactor (ANS 1988).

3.1.1.1 High Flux Beam Reactor. The 60 MW High Flux Beam Reactor is a heavy water

moderated and cooled research reactor which replaces an earlier 40 MW reactor. The High Flux Beam Reactor began operation in 1965. The High Flux Beam Reactor facility is composed of five buildings located on the 5,265-acre (2,131-hectare) site of the Brookhaven National Laboratory. The distance from the reactor to the nearest site boundary is to the south at 3700 feet (1288 meters). The spent nuclear fuel is stored in an 8-foot-wide, 43-foot-long, 20-foot-deep canal (2.4 meters wide, 13.2 meters long, 6.1 meters deep). Within the canal, the fuel is located in storage racks, either in a 30-cell rack or in a long-term storage rack (Carelli 1993).

3.1.1.2 Brookhaven Medical Research Reactor. The Brookhaven Medical Research

Reactor is a 5 MW heterogeneous, thermal, tank type reactor which is light water moderated and cooled. The reactor, used for research, became fully operational in 1959. The Brookhaven Medical Research Reactor is located in one building at the Brookhaven National Laboratory approximately 0.25 mile (0.4 kilometer) south of the High Flux Beam Reactor site. Fuel storage at the Brookhaven Medical Research Reactor consists of a shelf, lined with boral sheets, in the upper part of the reactor vessel above the active core region. The shelf is located under 8 feet (2.5 meters) of water and is considered critically safe when fully loaded. Like the High Flux Beam Reactor, there is no facility for dry storage at the Brookhaven Medical Research Reactor (Carelli 1993).

3.1.1.3 Affected Environment at Brookhaven National Laboratory.

3.1.1.3.1 Land Use-The Brookhaven National Laboratory is located approximately

60.
1 miles (97 kilometers) east of New York City on Long Island, New York. The site is located in a primarily suburban area. Land on the 5,265-acre (2,131-hectare) site is divided between undeveloped natural areas and the developed areas that support the laboratory's scientific research (BNL 1992c).

Regional land use includes a variety of residential, commercial, industrial, agricultural, institutional, recreational, and public uses. Although agricultural and undeveloped forest land have been the dominant land uses in the region, development pressures for residential and commercial land uses have increased steadily in recent years (BNL 1992c).

3.1.1.3.2 Socioeconomics-The Brookhaven National Laboratory is located in

central Suffolk County just at the fringe of developed areas, in an area of rapidly growing population.
About 1.32 million persons reside in Suffolk County and about 410,000 persons reside in Brookhaven Township, within which the Laboratory is situated. Between 1995 and 2040, population in Suffolk County is expected to increase 14.6 percent (DOC 1991a). Approximately 8,000 persons reside within a half mile (0.8 kilometer) of the laboratory boundary (BNL 1992b).

The population of Suffolk County is approximately 96 percent urban and has a substantially higher median family income than the rest of the state (DOC 1991c). Between 1970 and 1990, total employment in Suffolk County increased 103.8 percent (DOC 1992).

Dominant industries in the area include government, manufacturing, retail and services, with approximately 20 percent of earnings in Suffolk County coming from government spending (DOC 1992).

The Brookhaven National Laboratory is composed of a total staff of 3449 regular employees (BNL 1993a).

As reported in 1988, there were a total of 69 personnel working at the reactors (ANS 1988). This number included operators, experimenting scientists, and support personnel. While not their main occupation, part of the duties of the operators and some support personnel include tasks associated with refueling, storing, inventorying, packaging, and shipping SNF.

3.1.1.3.3 Cultural Resources-The Brookhaven National Laboratory has no

properties designated as National Historic Landmarks.

The Old Reactor Building (Building 701) and the Old Cyclotron Enclosure (Building 902) are eligible for inclusion on the National Register of Historic Places (NRHP). Camp Upton training trenches from World War I are also eligible for inclusion on the NRHP.

3.1.1.3.4 Geology-The Brookhaven National Laboratory site is in the upper part

of the Peconic River Valley, which is bordered by two lines of low hills. These extend east and west beyond the limits of the valley nearly the full length of Long Island and form its most prominent topographic features (ERDA 1977).

A maximum horizontal ground surface acceleration of 0.19 g at Brookhaven National Laboratory is estimated to result from an earthquake that could occur once every 2000 years (DOE 1994a). The seismic hazard information presented in this EIS is for general seismic hazard comparisons across DOE sites. Potential seismic hazards for existing and new facilities should be evaluated on a facility specific basis consistent with DOE orders and standards and site specific procedures.

No earthquake has yet been recorded in the Brookhaven National Laboratory area with a Modified Mercalli intensity in excess of III. Long Island lies in the Uniform Building Code Zone 2A (moderate) seismic hazard area. No active earthquake producing faults are known in the Long Island area (ERDA 1977).

3.1.1.3.5 Air Resources-In terms of meteorology, the laboratory can be

characterized, like most Eastern Seaboard areas, as a well-ventilated site. The prevailing ground-level winds are from the southwest during the summer, from the northwest during the winter, and about equally from these two directions during the spring and fall (BNL 1992b).

The mean annual temperature for the site during 1991 was 52.8yF (11.6yC), with temperatures ranging from 21.2yF (-6yC) to 83.8yF (28.8yC). The annual precipitation during 1991 was 45.3 inches (115 centimeters), which is about 3.6 inches (9.0 centimeters) below the 40-year annual precipitation average of 48.4 inches (123 centimeters) (BNL 1992b).

The State of New York has adopted ambient air quality standards that specify maximum permissible short- and long-term concentrations for various contaminants. These standards are generally the same as the national standards for criteria pollutants (NYSDEC 1977). Suffolk County, in which the site is located, is classified as being in nonattainment of the standards for the criteria pollutant ozone. The county is in attainment of standards for carbon monoxide, particluates, sulfur dioxide, nitrogen dioxide, and lead (NYSDEC 1993).

3.1.1.3.6 Water Resources-The Brookhaven National Laboratory site lies on the

western rim of the shallow Peconic River watershed. The marshy areas in the north and eastern sections of the site are a portion of the Peconic River headwaters. The Peconic River both recharges and receives water from the groundwater aquifer, depending on the hydrogeological potential. In times of drought the river water typically recharges to groundwater, while in times of normal to above normal precipitation, the river receives water from the aquifer (BNL 1992b).

Groundwater flow in the vicinity of Brookhaven National Laboratory is controlled by many factors. The main groundwater divide lies 1.25 to 5 miles (2 to 8 kilometers) south of Long Island Sound parallel to the Sound. This divide is known to shift 0.6 to 1.25 miles (1 to 2 kilometers), north to south. East of Brookhaven National Laboratory is a secondary groundwater divide that defines the southern boundary of the area contributing groundwater to the Peconic River. The exact location of the triple-point intersection of these two divides is not known and may be under Brookhaven National Laboratory. South of these divides, the groundwater moves southward to Great South Bay and to Moriches streams. In general, the groundwater from the area between the two branches of the divide moves out eastward to the Peconic River. North of the divide, groundwater moves northward to Long Island Sound. Pressure of a higher water table to the west of the Brookhaven National Laboratory area generally inhibits movement toward the west. Variability in the direction of flow in the Brookhaven National Laboratory site is a function of the hydraulic potential and is further complicated by the presence of clay deposits that accumulate perched water at several places plus the pumping/recharge of groundwater that are part of Brookhaven National Laboratory daily operations. In general, groundwater in the northeast and northwest sections of the site flows toward the Peconic River. On the western portion of the site, groundwater flow tends to be toward the south, while along the southern and southeastern sections of the site it tends to be toward the south to southeast (BNL 1992b).

In all areas of the site, horizontal groundwater velocity is estimated to range from 12 to 18 inches (30 to 45 centimeters) a day. The site occupied by Brookhaven National Laboratory has been identified by the Long Island Regional Planning Board and Suffolk County as being over a deep recharge zone for Long Island. This implies the precipitation and surface water which recharges within this zone has the potential to replenish the lower aquifer systems (Magothy and/or Lloyd) which exist below the Upper Glacial Aquifer. The extent to which the Brookhaven National laboratory site contributes to deep flow recharge is currently under evaluation. However, it is estimated that up to two-fifths of the recharge from rainfall moves into the deeper aquifers. These lower aquifers discharge to the Atlantic Ocean (BNL 1992b).

The three aquifers (Upper Glacial, Magothy and Lloyd) underlying the Brookhaven

National Laboratory comprise the Nassau/Suffolk Aquifer System, which has been designated as a sole source aquifer by the U.S. Environmental Protection Agency. More detailed aquifer characterization information can be found in the Brookhaven National Laboratory Site Baseline Report (SAIC 1992).

3.1.1.3.7 Ecological Resources-Approximately 75 percent of Brookhaven National

Laboratory is primarily woodland.
Terrestrial habitats include pine plantations, moderately mature pitch pine/oak forest, predominantly deciduous forest, early successional shrub/sapling community, pine barrens shrub/sapling wetlands, and lawn areas (BNL 1993a).

The isolation of the Brookhaven National Laboratory site and its variety of wildlife habitats have made it a refuge for a surprisingly diverse animal population. Thirty species of mammals have been recorded on site or within a 10-mile (16-kilometer) radius. All of these are year-round residents except for five summer-resident and two migrant species of bats. (BNL 1992c)

About 400 non-extinct species of birds have been recorded on all of Long Island since records have been kept, and at least 180 of these have been recorded on site. Thirty-three species are found throughout the year and all except six of these breed on site. Forty-nine other species are summer residents. All except nine nest on site, four others probably do, and the rest nest elsewhere on Long Island, most nearby (BNL 1993).

In September 1990, the U.S. Fish and Wildlife Service confirmed that no Federal or State endangered species occur in the vicinity of Brookhaven National Laboratory. However, the State endangered tiger salamander breeds in a pond in the southeast corner of the site (BNL 1992c).

3.1.1.3.8 Public Health and Safety-The calculated effective dose equivalent

associated with effluent releases from the most recent reports for a 5-year period are presented below (BNL 1993b, 1992a, 1992b, 1990, 1989).
The annual doses for each year are only a fraction of the DOE Public Dose Limit of 100 millirem per year. The data are from all laboratory operations, including storage of SNF.

Year	Airborne effluents (maximum site boundary)	Liquid effluents (maximum individual)
1988	0.113 millirem	0.15 millirem
1989	0.120 millirem	0.96 millirem
1990	0.067 millirem	0.85 millirem
1991	0.170 millirem	0.74 millirem
1992	0.097 millirem	0.91 millirem

The collective (population) dose equivalent (total population dose) beyond the site boundary, within a radius of 50 miles (80 kilometers), attributed to laboratory operations from reports for a 5-year period is presented below (BNL 1993b, 1992a, 1992b, 1990, 1989). The data are from all laboratory operations, including storage of SNF.

1988	2.5 person-rem
1989	3.2 person-rem
1990	1.8 person-rem
1991	3.6 person-rem
1992	3.2 person-rem

3.1.1.3.9 Waste Management-Brookhaven National Laboratory generates low-

level, low-level mixed and hazardous wastes, in conjunction with its activities as a scientific research center.
In 1992, the site generated approximately 508 tons (461 metric tons) of solid waste and 19.6 cubic yards (15 cubic meters) of liquid waste (DOE 1994b).

Brookhaven National Laboratory currently stores about 110 cubic yards (84 cubic meters) of low-level mixed waste and has no current or planned onsite treatment facilities. All waste streams are currently shipped to Hanford. These waste streams include organic liquids, acid and alkaline solutions, uranium hydride, cleaning/degreasing solvents, chromic acid cleaning solutions, and lead- and mercury-contaminated equipment (DOE 1993g).

In 1989, EPA listed BNL on the National Priorities Lists and in 1992 an Interagency Agreement was signed among DOE, EPA Region II, and the New York State Department of Environmental Conservation. Seven operable units have been identified for remedial investigation/feasibility studies and evaluated for suitable remedial action. The operable units consist of various groupings (generally by area) of buildings and sumps, underground pipes and tanks, the sewage runoff and discharge areas, trichloroethylene and reactor spill areas and groundwater. Some contamination at the site was the result of U.S. Army practices from 1917 to

1947 (DOE 1993g).

3.1.2 Los Alamos National Laboratory

The Omega West Reactor, operated by the Los Alamos National Laboratory, is a thermal, heterogeneous, closed-tank research reactor normally functioning at a power level of 8 MW. The Omega West Reactor was operational from 1956 until December 1992, when it was shut down. This reactor is permanently shut down and is being decommissioned. All spent nuclear fuel, consisting of 86 fuel elements, is in temporary storage at the Chemistry and Metallurgy Research Complex in Wing 9. They are being stored in old "Rover Project" casks which were once certified for transport of spent nuclear fuel. LANL has no permit for long-term storage of spent fuel.

3.1.2.1 Land Use. Los Alamos National Laboratory is located approximately 60 miles (96 kilometers) north-northeast of Albuquerque, New Mexico. Los Alamos occupies an area of about 28,000 acres (11,000 hectares) located primarily in Los Alamos County in northern New Mexico, about 24 miles (39 kilometers) northwest of Santa Fe. The County of Los Alamos has zoned the entire area of the lab Federal Land. Los Alamos National Laboratory has developed nine land use classifications for its operations. There are no prime farmlands on the Los Alamos National Laboratory, although portions are designated as a National Environmental Research Park (DOE 1993a).

3.1.2.2 Socioeconomics. The civilian labor force in the region of interest grew 144 percent, increasing from 34,467 in 1970 to 84,107 in 1990. Total employment increased from 31,155 to 79,846 between 1970 and 1990, an annual growth rate of 5 percent. The unemployment rates for 1970 and 1990 were 9.6 percent and 5.1 percent, respectively. For the same years, personal income increased from approximately $324.7 million to $2.3 billion (an annual average of 10 percent), and per capita income increased from $3,396 to $15,348 (DOE 1993a).

Between 1975 and 1990, employment at Los Alamos National Laboratory increased from 5,094 to 7,622, representing 10 percent of the region of interest employment in 1990. As of September 1992, employment at Los Alamos National Laboratory had increased to 7,450. The prepared Fiscal Year 1994 budget projects a reduction in expenditures at the site resulting in reduced employment (DOE 1993a).

In 1991, more than half of the Los Alamos National Laboratory workforce resided in the unincorporated communities of Los Alamos and White Rock in Los Alamos County. Between 1970 and 1990, the population in the region of interest increased 61 percent to 151,408. During the same period, the New Mexico population increased 49 percent. The population in the three-county region of interest is projected to increase from an estimated 169,000 in 2000 to 191,000 by 2020, an annual rate of less than 1 percent (DOE 1993a).

Employment associated with SNF management such as routine operations of the facility including care and periodic inventories of the SNF amounts to about 1.3 person-years per year (Cruz 1995).

3.1.2.3 Cultural Resources. The prehistoric chronology for the Los Alamos National Laboratory area consists of six broad time periods: Paleoindian (10,000-4000 B.C.), Archaic (5500 B.C.-A.D. 600), Early Developmental (A.D. 600-900), Late Developmental (A.D. 900-1100) Coalition (A.D. 1110-1325), and Classic (A.D. 1325-1600). Prehistoric site types identified in the vicinity of Los Alamos National Laboratory include large multiroom pueblos, pithouse villages, field houses, talus houses, cave kivas, shrines, towers, rockshelters, animal traps, hunting blinds, water control features, agricultural fields and terraces, quarries, rock art, trails, campsites, windbreaks, rock rings, and limited activity sites. Approximately 75 percent of Los Alamos National Laboratory has been inventoried for cultural resources. Coverage for some inventories has been less than 100 percent; however, about 60 percent of Los Alamos National Laboratory has received 100 percent coverage. Over 975 prehistoric sites have been recorded; about 95 percent of these sites are considered eligible or potentially eligible for the National Register of Historic Places (DOE 1993a).

Native Americans in this area include those living in the San Ildefonso, San Juan, Santa Clara, Nambe, Tesuque, Pojoaque pueblos east of Los Alamos, and the Jemez and Cochiti pueblos. Native American resources on Los Alamos National Laboratory may consist of prehistoric sites with ceremonial features such as kivas, village shrines, petroglyphs, or burials; all of these site types or features would be of concern to local groups (DOE 1993a).

3.1.2.4 Geology. Los Alamos National Laboratory is located on the Pajarito Plateau.

The surface of the plateau is dissected by deep, southeast-trending canyons separated by long, narrow mesas (DOE 1993a).

Los Alamos National Laboratory lies in the Uniform Building Code Zone 2B seismic hazard area. The strongest earthquake in the last 100 years within a 50-mile (80-kilometer) radius was estimated to have a magnitude of 5.5 to 6 and a Modified Mercalli Intensity of VII. Studies suggest that several faults have produced seismic events with a magnitude of 6.5 to 7.8 in the last 500,000 years. Los Alamos National Laboratory operates a seismic hazards program which monitors seismicity through a seismic network and conducts studies in paleoseismology. These studies have determined the presence of three faults in the area that are considered active as defined by 10 CFR 100, Appendix A. These form the Pajarito fault system, which includes the Pajarito, Water Canyon, and Guaje Mountain faults. The Guaje Mountain fault had movement on it between 4,000 and 6,000 years ago. There is no evidence of movement along the Pajarito fault system during historical times. The 100-year earthquake at Los Alamos is regarded as having a magnitude of 5, with an event of magnitude 7 being the maximum reasonably foreseeable earthquake. These values are currently used in design considerations at Los Alamos (DOE 1993a).

Maximum horizontal ground surface accelerations ranging from 0.17 to 0.25g at Los Alamos National Laboratory are estimated to result from an earthquake that could occur once every 2000 years (DOE 1994a). The seismic hazard information presented in this EIS is for general seismic hazard comparisons across DOE sites. Potential seismic hazards for existing and new facilities should be evaluated on a facility specific basis consistent with DOE orders and standards and site specific procedures.

Geological concerns associated with the Los Alamos National Laboratory area include potential downslope movements in association with regional seismic activity. Although isolated rockfalls commonly occur from the canyon rims, landslides are an unlikely hazard (DOE 1993a).

3.1.2.5 Air Resources. The climate at Los Alamos National Laboratory and in the

surrounding region is characterized as a semiarid tropical and subtropical steppe. Mountain barriers deplete a large portion of the moisture from the maritime air masses from the Pacific Ocean, a condition that contributes to the semiaridness. The annual average temperature in the area is 56.2oF (13.4oC); average daily temperatures range from 22.3oF (-5.4oC) in January to 92.8oF (33.8oC) in July. The average annual precipitation in the area is 8.1 inches (20.6 centimeters). The average monthly precipitation ranges from 0.38 inch (0.97 centimeter) in November to 1.51 inches (3.84 centimeters) in August (DOE 1993a).

3.1.2.6 Water Resources. The major surface water body in the immediate vicinity of Los

Alamos National Laboratory is the Rio Grande east of the site. The primary surface water features near Los Alamos National Laboratory are intermittent streams. Sixteen drainage areas pass through or start in the Los Alamos National Laboratory site. Most Los Alamos National Laboratory facilities are located well above the streambeds. Only those Technical Areas located within canyons would be within the 500-year floodplain (DOE 1993a).

No surface water is withdrawn at Los Alamos National Laboratory for either drinking water or facility operations. The water supply system for Los Alamos is based on a series of groundwater supply wells and springs (DOE 1993a).

Los Alamos, Sandia, and Mortandad canyons currently receive treated industrial or sanitary effluent. Acid-Pueblo Canyon does not receive Los Alamos National Laboratory effluents. Surface waters in these canyons are not a source of municipal, industrial, or agricultural water supply. Only during periods of heavy precipitation or snow melt would waters from Acid-Pueblo, Los Alamos, or Sandia Canyons extend beyond Los Alamos National Laboratory boundaries and reach the Rio Grande. In Mortandad Canyon, there has been no surface runoff to the laboratory's boundary since studies were initiated in 1960 (DOE 1993a).

The main aquifer consists mainly of sediments of the Santa Fe Group. Nearly all groundwater at Los Alamos National Laboratory is obtained from deep wells that produce water from this aquifer. The Bandelier Tuff, a volcanic unit that lies above the Santa Fe Group, contains fractures that yield small amounts of water to springs. A minor amount of groundwater at Los Alamos National Laboratory is obtained from springs. The aquifers that lie beneath Los Alamos National Laboratory are considered Class II aquifers, having current sources of drinking water and water with other beneficial uses (DOE 1993a).

The water in the main aquifer moves slowly from the major recharge area in the west to discharge springs in White Rock Canyon along the Rio Grande. The depth to the aquifer ranges from about 1,200 feet (365 meters) on the west to about 600 feet (183 meters) on the east. The total saturated thickness penetrated by production wells ranges up to at least 1,700 feet

(518 meters) (DOE 1993a).

3.1.2.7 Ecological Resources. Terrestrial habitats within undeveloped areas of Los

Alamos National Laboratory support six major vegetative communities: juniper-grassland, pinyon pine-juniper, ponderosa pine, mixed conifer, spruce-fir, and subalpine grassland. Undeveloped areas within Los Alamos National Laboratory provide habitat for a diversity of terrestrial wildlife.

Los Alamos National Laboratory was designated a National Environmental Research Park in 1976 (DOE 1993a).

National Wetland Inventory maps indicate that wetlands within Los Alamos National Laboratory are restricted to several canyons containing the Rio Grande or its tributaries. Most of the wetlands shown on the National Wetland Inventory maps have been designated as temporary or seasonal (DOE 1993a).

Aquatic habitats on Los Alamos National Laboratory are limited to the Rio Grande and several springs and intermittent streams in the canyons. These habitats currently receive National Pollutant Discharge Elimination System-permitted wastewater discharges. Fourteen species of fish are known to inhabit the roughly 6-mile (10-kilometer) reach of the Rio Grande between Los Alamos National Laboratory and Chochiti Lake. The springs and streams on the site support limited, if any, aquatic life (DOE 1993a).

Seventeen federally listed or New Mexico-listed threatened, endangered, or candidate species potentially occur in the vicinity of Los Alamos National Laboratory. Four of these species have been observed on Los Alamos National Laboratory, including the bald eagle (Haliaeetus leucocephalus)(a federally listed endangered species that roosts along the Rio Grande); the peregrine falcon (Falco peregrinus)(a federally listed endangered species that historically nests in the northeast corner of Los Alamos National Laboratory); the northern goshawk (Accipiter gentilis) (A Federal candidate Category 2 species that forages in the northwest corner of Los Alamos National Laboratory); and the giant helleborine orchid (Epipactic gigantea) (a state-listed endangered species that occurs near springs in White Rock Canyon). Five other species occur in close proximity to Los Alamos National Laboratory and are likely to exist on the site (DOE 1993a).

3.1.2.8 Public Health and Safety. The total maximum individual dose to a member of

the public associated with both gaseous and liquid effluents from the most recent reports for a 5-year period is presented below (LANL 1993, 1992, 1990, 1989, 1988). The annual doses for each year are only a fraction of the DOE Public Dose Limit of 100 millirem per year. The data are from all laboratory operations, including storage of SNF.

1987	6.1 millirem
1988	6.2 millirem
1989	3.9 millirem
1990	3.1 millirem
1991	4.4 millirem

The population collective effective dose equivalent attributable to laboratory operations to persons living within 50 miles (80 kilometers) of the laboratory for a 5-year period is presented below (LANL 1993, 1992, 1990, 1989, 1988). The data are from all laboratory operations, including storage of SNF.

1987	3.5 person-rem
1988	2.2 person-rem
1989	3.1 person-rem
1990	3.1 person-rem
1991	1.1 person-rem

3.1.2.9 Waste Management. Current low-level radioactive waste management activities

at Los Alamos National Laboratory may require expansion of the existing landfill at Los Alamos National Laboratory. A portion of the proposed expansion area for the existing landfill has been contaminated by a chemical plume from the hazardous chemical disposal site, which restricts further development. DOE is considering the expansion to ensure continued operation of laboratory activities that generate low level radioactive waste and to provide safe isolation of the wastes (DOE 1993a).

Waste minimization has been implemented by Los Alamos National Laboratory's Environmental Management Division using programmatic controls such as source reduction, inventory control, product substitution, and waste exchange programs. A Waste Minimization and Pollution Prevention Awareness Plan was completed in 1991. Major waste generating operations have been prioritized by severity of hazard and volume in order to determine which generating systems to address. Also, halogenated solvent substitution has been evaluated for a number of research processes (DOE 1993a).

3.1.3 Sandia National Laboratories

Sandia National Laboratories, headquartered in Albuquerque, New Mexico, maintain facilities in three locations: Albuquerque, New Mexico; Livermore, California; and Tonopah, Nevada. The facilities discussed in this document refer only to the Albuquerque location, located adjacent to the city of Albuquerque, New Mexico. The site is approximately 6.5 miles (10 kilometers) southeast of downtown Albuquerque. Sandia National Laboratories consist of 8,300 acres (3,360 hectares) on Kirtland Air Force Base allocated to DOE.

Sandia National Laboratories use facilities at five Technical Areas and a Test Field (DOE 1993a).

- Technical Area I--Administration, site support, technical support, component development, research, energy programs, microelectronics, defense programs, and exploratory systems.
- Technical Area II--Testing of explosive components.
- Technical Area III--Testing and simulation of a variety of natural and induced environments, including two rocket sled tracks, two centrifuges, and a radiant heat facility.
- Technical Area IV--A remote site for pulsed power sciences such as X-ray, gamma-ray, and particle beam fusion accelerators.
- Technical Area V--A remote area for experimental and engineering reactors and particle accelerators.
- Coyote Test Field--Land parcels scattered throughout the Coyote Test Field used for testing.

The Sandia National Laboratories contain five SNF storage facilities: the Manzano Storage Structures, the Annular Core Research Reactor Facility, the Sandia Pulse Reactor Facility, the Hot Cell Facility, and the Special Nuclear Materials storage facility (DOE 1993b).

3.1.3.1 Manzano Storage Structures. The Manzano Storage Structures are reinforced

concrete bunkers located in the southeast portion of Kirtland Air Force Base. Until recently, when the Sandia National Laboratories took responsibility for the site, the Manzano facilities were operated and maintained by the Department of Defense. The Sandia National Laboratories currently use four structures for dry storage of reactor irradiated nuclear material.

The two types of bunkers which Sandia National Laboratories utilize are reinforced concrete bunkers with an earth covering, and reinforced concrete bunkers bored into the mountain. The average storage space available is 1800 square feet (167 square meters). A ring road encircles the mountain and provides access to all of the bunkers. The ventilation is natural air circulation (DOE 1993b).

3.1.3.2 Annular Core Research Reactor. The Annular Core Research Reactor is a pool-

type research reactor capable of steady-state, pulse, and tailored transient operation. The reactor has a large central irradiation cavity (primary experiment location) that extends through the core, two interchangeable, fuel-ringed external cavities, an unfueled external cavity and two neutron radiography facilities. The Annular Core Research Reactor facility includes the reactor pool, one safe, and eight dry floor storage vaults, all located in the high-bay of Building 6588. The Annular Core Research Reactor is used primarily for testing electronics and for reactor safety research. The eight storage vaults on the high-bay floor are used to securely store irradiated experiments containing a variety of nuclear materials, but principally uranium-235. Materials from only three experiments containing reactor irradiated nuclear materials are stored at the Annular Core Research Reactor (DOE 1993b).

3.1.3.3 Sandia Pulse Reactor II and III, and Critical Assembly. Three reactors are

operated at the Sandia Pulse Reactor facility; Sandia Pulse Reactor II and Sandia Pulse Reactor III are unmoderated, fast-burst reactors capable of pulsed and steady-state operation. They are designed to produce a neutron energy spectrum similar to that produced from fission. The primary experiment location for each reactor is a central cavity that extends through the core. The principal use of the reactors is to irradiate electronic devices requiring high neutron fluence and/or high dose rates. The Critical Assembly is a small, water-moderated reactor used to perform measurements of key reactor parameters to benchmark the computer calculations and thereby refine the designs for a planned space propulsion reactor. The yard storage holes are 19 stainless-steel types located in a corner of the Sandia Pulse Reactor compound. These tubes are surrounded by a high-density concrete monolith. The yard holes are used to securely store irradiated experiments containing a variety of nuclear materials, but principally uranium-235. All of the materials reside in their own containers, some of which have double containment (DOE 1993b).

3.1.3.4 Hot Cell Facility. The Hot Cell Facility at Sandia National Laboratories is a

nonreactor nuclear facility that is housed in Building 6580 in Technical Area V. The Hot Cell Facility includes the Hot Cell, the Glove Box Laboratory, Radiochemistry Laboratory, and support facilities in rooms 101, 104, 105, 106, 107, 108, 110, 111, 112, 113, 113A, 203, and 212A. This facility is designed to permit safe handling and experimentation with Special Nuclear Materials, both irradiated and unirradiated. Research programs at Sandia National Laboratories (material studies, fuel studies, and safety studies) require that experiments containing radioactive materials be assembled and/or disassembled, samples prepared, and microscopic and chemical analyses performed. The principal storage facility for the Hot Cell Facility is Room 108, which is a heavily shielded room used previously as a preparation room next to the irradiation room of the Sandia Engineering Reactor which has been defueled. There are a series of 13 storage holes under the Hot Cell Facility Monorail that are available to store irradiated material coming into or out of the Hot Cell Facility. Only one of the holes is currently in use. The other areas of the Hot Cell Facility are used for storing minor amounts of material (DOE 1993b).

3.1.3.5 Special Nuclear Material Storage Facility. At this dry storage facility, Sandia

National Laboratories stores previously failed fuel elements from Sandia Pulse Reactor II and elements from experiments that have been exposed to short irradiation periods. The complex also provides for a loading area, a maintenance area, and an administrative office area. The ventilation consists of a forced air filtered system (DOE 1993b).

3.1.3.6 Affected Environment at Sandia National Laboratories.

3.1.3.6.1 Land Use-Sandia National Laboratories are located approximately

6.
5 miles (10.5 kilometers) southeast of downtown Albuquerque, New Mexico. There are no prime farmlands on Sandia National Laboratories (DOE 1993a).

3.1.3.6.2 Socioeconomics-The civilian labor force in the region of interest grew

132 percent, increasing from 133,798 in 1970 to 310,252 in 1990. Total employment increased from 124,605 to 293,905 between 1970 and 1990, an annual growth rate of 4 percent. The unemployment rates for 1970 and 1990 were 6.9 percent and 5.3 percent, respectively. For the same years, personal income increased from approximately $1.3 billion to $9.4 billion (an annual average of 10 percent), and per capita income increased from $3,438 to $15,992 (DOE 1993a).

Between 1970 and 1990, employment levels at Sandia National Laboratories increased from 6.440 to 7,536, representing 3 percent of the region of interest employment in 1990. Changes in mission requirements have historically led to fluctuations in employment levels over the period. For example, employment decreased to 5,542 in 1975 and increased to 7,051 by 1985. As of September 30, 1992, employment levels at Sandia National Laboratories had increased to 8,473. The prepared Fiscal Year 1994 budget projects a reduction in expenditures at the site, resulting in reduced employment. The reduction in work force associated with the budget reductions is only estimated at this time (DOE 1993a).

Between 1970 and 1990, the population in the region of interest increased 58 percent to 589,131. During the same period, the population of New Mexico increased 49 percent. The population in the three-county region of interest is projected to increase from an estimated 682,000 in 2000 to 771,000 by 2020, an annual rate of less than 1 percent (DOE 1993a).

As reported in 1988, there were a total of 21 personnel working at the reactors (ANS 1988). This number included operators, experimenting scientists, and support personnel. While not their main occupation, part of the duties of the operators and some support personnel include tasks associated with refueling, storing, inventorying, packaging, and shipping SNF.

3.1.3.6.3 Cultural Resources-The prehistoric chronology for the Sandia National

Laboratories area consists of three broad time periods: Paleoindian (10,000-5500 B. C.), Archaic (5500 B.C.-A.D. 1), and Anasazi (A.D. 1600). Prehistoric site types include pueblos, pithouse villages, rockshelters, hunting blinds, agricultural terraces, quarries, lithic and ceramic scatters, lithic scatters, and hearths. About 22 percent of Sandia National Laboratories/DOE-controlled land has been intensively inventoried for cultural resources; another 28 percent has received less intensive surveys. Because techniques and procedures varied greatly between projects in these areas, most surveys are not considered adequate. All five DOE Technical Areas have been intensively surveyed; no prehistoric sites were recorded. Sixty-four prehistoric sites have been recorded in DOE-owned or controlled lands beyond the five Technical Areas. About 88 percent of these sites are considered eligible for the National Register of Historic Places (DOE 1993a).

Native Americans in this area include those living on the Sandia Pueblo, north of Albuquerque, and the Isleta Pueblo, south of Kirtland Air Force Base. Native American resources on Sandia National Laboratories/DOE-controlled lands may consist of prehistoric sites with ceremonial features such as kivas, village shrines, petroglyphs, or burials; all of these types or features would be of concern to local groups (DOE 1993a).

3.1.3.6.4 Geology-Sandia National Laboratories lie on a sequence of sedimentary,

igneous, and Precambrian basement rocks. The northern and western sections of Sandia National Laboratories rest on Miocene to Quaternary gravels, sands, silts, and clays deposited in the basin formed by uplift of the mountains to the east. The eastern portion of Sandia National Laboratories is underlain primarily by Precambrian rocks (DOE 1993a).

The eastern portion of Sandia National Laboratories is cut by the Tijeras, Hubble Springs, Sandia, and Manzano faults. Both the Tijeras and Sandia faults, which intersect on the site, are considered capable faults (DOE 1993a).

Sandia National Laboratories lies in the Uniform Building Code 2B seismic hazard area. The facility is situated in a region of high seismic activity but low magnitude and intensity. Available records indicate that more than 1,100 earthquakes have occurred during the past 127 years. However, during the past century, only three have caused damage at Albuquerque. Intensities have been as high as a Modified Mercalli Intensity of VII, which can cause damage (DOE 1993a).

Possible geological concerns include potential ground shaking and rupturing associated with regional seismic activity and the two capable faults intersecting on the site. Statistical studies indicate that a nondamaging earthquake (Modified Mercalli Intensity less than III) may be expected every 2 years, with a damaging event every 100 years (DOE 1993a).

A maximum horizontal ground surface acceleration of 0.28g at Sandia National Laboratory is estimated to result from an earthquake that could occur once every 2000 years (DOE 1994a). The seismic hazard information presented in this EIS is for general seismic hazard comparisons across DOE sites. Potential seismic hazards for existing and new facilities should be evaluated on a facility specific basis consistent with DOE orders and standards and site specific procedures.

3.1.3.6.5 Air Resources-The climate at Sandia National Laboratories and in the

surrounding region is characteristic of a semiarid steppe. The annual average temperature in the area is 56.2oF (13.4oC); temperatures vary from an average daily minimum of 22.3oF (-5.4oC) in January to an average daily maximum of 92.8oF (33.8oC) in July. The average annual precipitation is 8.1 inches (20.6 centimeters) (DOE 1993a).

3.1.3.6.6 Water Resources-Sandia National Laboratories are located within the

Kirtland Air Force Base on the Albuquerque East Mesa. The mesa slopes gently southwest to the Rio Grande, the primary drainage channel for the area. The average flow of the Rio Grande is 1,008 cubic feet (28.5 cubic meters) per second. No perennial streams flow through the Sandia National Laboratories area. The two primary surface channels at Sandia National Laboratories are Tijeras Arroyo and the smaller Arroyo del Coyote. The Arroyo del Coyote joins the Tijeras Arroyo to discharge into the Rio Grande approximately 5 miles (8 kilometers) from the western edge of Kirtland Air Force Base. Both arroyos flow intermittently during spring snow melt or following thunderstorms. Springs in the eastern mountains provide a perennial flow in the upper reaches of Tijeras Arroyo. Most of this flow evaporates or percolates into the soil before reaching Kirtland Air Force Base (DOE 1993a).

High peak flows of short duration characterize floods in the area. High-intensity summer thunderstorms produce the greatest flows, but the probability of flooding is not considered high at Kirtland Air Force Base. The southeast corner of Technical Area IV and the east side of Technical Area II lie within the 500-year floodplain of Tijeras Arroyo (DOE 1993a).

Sandia National Laboratories lie within the north-south trending Albuquerque basin. The principal aquifer of the Albuquerque basin is the Valley Fill aquifer. The Valley Fill consists of unconsolidated and semiconsolidated sands, gravels, silts, and clays that vary in thickness from a few feet (meters) adjacent to the mountain ranges to over 21,000 feet (6,400 meters) at a point 5 miles (8 kilometers) southwest of Kirtland Air Force Base airfield. The Valley Fill aquifer is considered a Class IIa aquifer, having a current source of drinking water and waters with other beneficial uses. (DOE 1993a)

The regional water table is separated by a fault complex that divides the area into a deep region on the west side of the complex and a shallower region on the east side. The depth to groundwater ranges from 50 to 100 feet (15 to 30 meters) on the east side of the fault complex and from 380 to 500 feet (115 to 1150 meters) on the west side. Based on available data, the apparent direction of groundwater flow west of the fault complex is generally to the north and northwest. The direction of groundwater flow east of the fault complex typically is west toward the fault system (DOE 1993a).

3.1.3.6.7 Ecological Resources-Most undeveloped lands within Technical Areas I

and III of Sandia National Laboratories support grassland vegetation. Terrestrial wildlife using grassland habitats on Sandia National Laboratories are typical of similar habitats in central New Mexico. The size and diversity of wildlife populations are thought to be limited by the poor availability of water. An inventory of wildlife species on Kirtland Air Force Base (including Sandia National Laboratories) has been recently updated (DOE 1993a).

No wetland inventories have been performed for Sandia National Laboratories, and no National Wetland Inventory maps have been published. Several springs exist on Kirtland Air Force base, including Sol se Mete Spring, Coyote Springs, and G Spring. These are associated with canyons and arroyos. No springs exist in Technical Areas I through V, and none are located within permitted land to which Sandia National Laboratories has access (DOE 1993a).

Potential aquatic habitat within Kirtland Air Force Base is limited to arroyos and canyons and the few springs associated with them. The nearest major perennial aquatic habitat is the Rio Grande, approximately 5 miles (8 kilometers) to the west (DOE 1993a).

No federally listed threatened or endangered species are known to occur on Sandia National Laboratories. The peregrine falcon (Falco peregrinus), a federally and state-listed endangered species, could potentially occur in the mountainous areas of Kirtland Air Force Base surrounding Sandia National Laboratories, but the likelihood is low because of the poor quality habitat for this species. The grama grass cactus (Pediocactus papyracanthus), a Federal Candidate Category 2 and state-listed endangered species, is known to occur in grasslands on Kirtland Air Force Base similar to those occurring on Sandia National Laboratories. The spotted bat (Euderma maculatum), also a Federal Category 2 and state-endangered species, has a low probability of occurrence on Sandia National Laboratories. Sandia National Laboratories lie within the breeding range of several Federal Candidate bird species (DOE 1993a).

3.1.3.6.8 Public Health and Safety-The annual dose to a maximally exposed

individual due to release of gaseous radionuclides from laboratory operations from reports for a 5-year period is presented below (SNL 1993, 1992, 1991, 1990, 1989). The data are from all laboratory operations, including storage of SNF.

1988	0.00034 millirem
1989	0.00088 millirem
1990	0.0020 millirem
1991	0.0014 millirem
1992	0.0034 millirem

The estimated population dose to persons living within a 50-miles (80-kilometer) radius surrounding the laboratory due to release of gaseous radionuclides from laboratory operations from reports for a 5-year period is presented below (SNL 1993, 1992, 1991, 1990, 1989). The data are from all laboratory operations, including storage of SNF.

1988	0.039 person-rem
1989	0.097 person-rem
1990	0.82 person-rem
1991	0.052 person-rem
1992	0.020 person-rem

3.1.3.6.9 Waste Management-Low-level radioactive waste at Sandia National

Laboratories is generated in both technical and remote test areas as a result of research and development activities.

Most of the low-level radioactive waste consists of contaminated equipment and combustible decontamination materials and cleanup debris. All generated low-level radioactive waste is temporarily stored at generator sites or above ground in transportation containers at the Technical Area III disposal site. All low-level radioactive waste packages are currently onsite pending approval of transport by commercial carriers offsite for burial (DOE 1993a).

Mixed wastes include radioactively contaminated oils and solvents and radioactively contaminated or activated lead or other heavy metals. Other mixed wastes may be generated as a result of weapons tests (DOE 1993a).

3.1.4 Argonne National Laboratory - East

The Argonne National Laboratory - East stores reactor irradiated nuclear materials in the Alpha-Gamma Hot Cell (Building 212, Wing F), the Chicago Pile 5 Building, and analytical laboratories within Building 205. The principal mission (past and present) of the Alpha-Gamma Hot Cell is research on the behavior of materials, fuel, and structures used in nuclear reactors. Chicago Pile 5 houses a shut-down, heavy-water, moderated reactor whose fuel has been removed and shipped offsite. Currently Chicago Pile 5 is in the process of being decontaminated and decommissioned and contains only two highly enriched uranium target (i.e., converter) elements. Building 205 contains analytical laboratories that perform analyses on gram quantities of SNF samples coming from the Alpha-Gamma Hot Cell (DOE 1993b).

3.1.4.1 Land Use. The laboratory and support facilities occupy about a 200-acre

(81-hectare) tract; 1,700 acres (688 hectares) within the site perimeter are devoted to forest and landscaped areas. The Dupage County Forest Preserve District operates 2,040-acre (826-hectare) green belt forest preserve, known as the Waterfall Glen Forest Preserve, which surrounds the site. Much of this forest preserve was formerly Argonne National Laboratory property but was deeded to the Forest Preserve District in 1973 for use as a public recreation area, nature preserve, and demonstration forest. In the past few years, a number of industrial parks have been constructed to the north and northwest of the laboratory. Also, many commercial establishments and a large number of dwelling units have been constructed within a few miles (kilometers) of Argonne National Laboratory. Before being occupied by Argonne National Laboratory, most of the site was wooded and the remaining land was used for farming (ANL-E 1993a).

3.1.4.2 Socioeconomics. Argonne National Laboratory is located within the Chicago

Standard Metropolitan Statistical Area, which comprises six Illinois and two Indiana counties around the southwest corner of Lake Michigan. The population between 1970 and 1990 in the region increased 1.2 percent from 6,491,300 to 6,568,800 people. During this time total Illinois population increased 2.9 percent. Data sources for this information include U.S. Bureau of the Census, Bureau of Economic Analysis, and Department of Energy documents (DOC 1992).

The nearby areas of Will and Cook Counties have generally developed at a considerably lower rate than has the DuPage County area, except along the Illinois Waterway where industrial development has taken place. Included within a 50-mile (80-kilometer) radius are portions of Lake and Porter Counties in Indiana, and all of DuPage, Will, Cook, Kendall, and Kane Counties in Illinois (DOC 1992).

Beyond the forest preserve at Argonne National Laboratory's perimeter, the population density is low, except for a high-density residential area--over 15 units per acre (37 units per hectare) and about 4,500 residents--beginning some 650 yards (600 meters) east of the perimeter. DuPage County's growth rate has been the highest of any metropolitan Illinois county. In 1990, the total number of housing units within region equaled 2,548,736. Cook County contained the largest percentage of the region's housing units (DOC 1991b).

With its workforce of about 4,700 persons, Argonne National Laboratory is one of the three largest employers in DuPage County. Employees commute to Argonne National Laboratory from distances as far as 30 miles (50 kilometers); thus the payroll is spread over a wide area. However, nearby villages, notably Lemont and Downers Grove, do house high numbers of Argonne National Laboratory employees. About 50 percent of Argonne National Laboratory employees reside within 10 miles (16 kilometers) of the site. The laboratory also purchases much of its utilities, outside services, equipment, and supplies locally (DOC 1992).

Employment associated with SNF management such as routine operations of the facility including care and periodic inventories of the SNF amounts to about 0.5 person-years per year (Neimark 1995).

3.1.4.3 Cultural Resources. The ANL-E site has no properties designated as National

Historic Landmarks or listed on the National Register of Historic Places.

In 1992, 26 archaeological properties had been recorded at ANL-E. One site has been evaluated as being potentially eligible for the National Register, 19 sites are not considered eligible, and 6 sites have not been evaluated (ANL-E 1993a).

The Illinois State Historic Preservation Agency has not evaluated the ANL-E site's potential to contain additional unidentified archaeological or architectural resources. The potential of the ANL-E site to contain traditional cultural resources of interest to Native American groups has not been evaluated (ANL-E 1993a).

3.1.4.4 Geology. The topography at ANL-E is generally gently rolling; the average

elevation is 725 feet (221 meters) above sea level. Slopes of consequence are found only adjacent to streams and near the southern edge of the site, where the fall into the Des Plaines River Valley begins (ANL-E 1993b). The geology of the Argonne National Laboratory area consists of about a 100-foot-thick (30-meter-thick) deposit of glacial till on top of dolomite bedrock. The bedrock at Argonne National Laboratory is the Niagaran and Alexandrian dolomite of Silurian age (about 400 million years old). These formations are underlain by Maquoketa shale of Ordovician age, and older dolomites and sandstones of Ordovician and Cambrian age. The beds are nearly horizontal (ANL-E 1993b).

The Niagaran and Alexandrian dolomite are about 200 feet (60 meters) thick in the Argonne National Laboratory area, and are widely used in DuPage County as a source of groundwater. The Maquoketa shale separates the upper dolomite aquifer from the underlying sandstone and dolomite aquifers. This shale retards hydraulic connection between the upper and lower aquifers; the lower aquifer has a much lower piezometric level and does not appear to be affected by pumpage from the overlying Silurian bedrock (ANL-E 1993a).

A capable fault is one that has had movement at, or near, the ground surface at least once within the past 35,000 years or recurring movement within the past 500,000 years (10 CFR 100, Appendix A). A few minor earthquakes have occurred in northern Illinois, believed to have been caused by isostatic adjustments of the Earth's crust in response to glacial unloading. Several areas of seismic activity are present at moderate distances from ANL-E, including the New Madrid Fault zone in the St. Louis area of southwestern Missouri, the Wabash Valley Fault zone along the southern Illinois-Indiana border, and the Anna region of western Ohio. Ground motions induced by near and distance seismic sources are expected to be minimal at the Laboratory (ANL-E 1993a).

A maximum horizontal ground surface acceleration of 0.15g at Argonne National Laboratory - East is estimated to result from an earthquake that could occur once every 2000 years (DOE 1994a). The seismic hazard information presented in this EIS is for general seismic hazard comparisons across DOE sites. Potential seismic hazards for existing and new facilities should be evaluated on a facility specific basis consistent with DOE orders and standards and site specific procedures.

No active volcanoes are considered to be in the ANL-E region (Keller 1979). Therefore, the potential for damage from volcanic activity is minimal.

The major soil type present at ANL-E is Morley silt loam. This soil covers approximately 70 percent of the site. Stream valley soils, including the Askum, Peotone, and Sawmill silty clay loams, cover approximately 15 percent of the site, urban land soils approximately 10 percent, and other minor soils the remaining 5 percent (Mapes 1979).

3.1.4.5 Air Resources. The regional climate around Argonne National Laboratory is

characterized as being continental, with relatively cold winters and hot summers. The area is subject to frequently changing weather as storm systems move from the Great Plains toward the east. The weather is slightly modified by Lake Michigan, which is about 22 miles (35 kilometers) east-northeast of the Laboratory (ANL-E 1993a).

Meteorological data presented here were compiled from the National Weather Service Station at the O'Hare International Airport in Chicago and from the meteorological tower operated at ANL-E. The prevailing winds for the airport are from the south and southwest with a northeast component. The frequency of calm winds, defined as those less than 2 miles per hour (1 meter per second), was approximately 4 percent. The 1992 average wind rose for the ANL-E site is very similar to this pattern, with prevailing winds from the west to south, but with a more significant northeast component. In 1992, the percentage of calm winds at ANL-E was approximately 3 percent (ANL-E 1993a).

The amount of rainfall recorded in 1992, 31.5 inches (80.01 centimeters), was nearly identical to the site's historical average of 31.48 inches (79.95 centimeter). The temperatures recorded during 1992 were also similar to the site's long-term averages. The coldest months during 1992 were January and December, with monthly averages of 27.9yF (-2.3yC) and 28.0yF (-2.2yC), respectively. The warmest months were July and August, with monthly averages of 68.5yF (20.3yC) and 66.9yF (19.4yC), respectively (ANL-E 1993a).

The area experiences about 40 thunderstorms annually. Occasionally, these storms are accompanied by hail, damaging winds, or tornadoes. From 1957 to 1969 there were 371 tornadoes in the state, with more than 65 percent occurring in the spring months. The theoretical probability of a tornado strike at Argonne is 8.54 x 10-4 each year, or a recurrence interval of 1 tornado every 1,200 years. The Argonne National Laboratory site was struck by tornadoes in 1976 and 1978, with minor damage to power lines, roofs, and trees.

The State of Illinois has adopted ambient air quality standards that specify maximum permissible short- and long-term concentrations of various contaminants (State of Illinois Rules and Regulations 1992). These standards are the same as the National Ambient Air Quality Standards for criteria pollutants (NAAQS; 40 CFR 50). In addition to standards for criteria pollutants, the Illinois Environmental Protection Agency has made applicable all regulations promulgated by the EPA relating to National Emission Standards for Hazardous Air Pollutants (NESHAP), under Section 112 of the Clean Air Act (40 USC 7412, 7601a).

The ANL-E site and the surrounding counties are classified by the EPA as severe nonattainment areas for the criteria pollutant ozone (O3). All other surrounding counties and areas are in attainment of the remaining National Ambient Air Quality Standards criteria pollutants: nitrogen dioxide (NO2), sodium dioxide (SO2), lead (Pb), particulate matter less than 10 microns in diameter (PM10) and carbon monoxide (CO) (with the exception of the Lyons Township in southeast Chicago, which is listed as a moderate nonattainment area for PM10) (ANL-E 1993b).

3.1.4.6 Water Resources.

Surface Water - The ANL-E is in the Des Plaines River drainage basin 24 miles (39 kilometers) west of Lake Michigan and is on the northern margin of the Des Plaines River valley. The largest onsite stream is Sawmill Creek, which originates north of the site and enters the Des Plaines River about 1.25 miles (2.01 kilometers) southeast from the center of the site. Two small streams originate onsite and combine to form Freund Brook, which discharges into a Sawmill Creek. Most of ANL-E is drained by Freund Brook. The Des Plaines River flows southwest about 30 miles (48 kilometers) until it joins with the Kankakee River to form the Illinois River (ANL-E 1993a). As noted in National Wild and Scenic Rivers System, December 1992 (USGS, 1992) the ANL-E region has no federally designated wild and scenic rivers.

Flow in Sawmill Creek, upstream from the ANL-E wastewater outfall, averaged 6.3 cubic feet (0.18 cubic meters) per second in 1992. Flow in the Des Plaines River near the site is approximately 900 feet3 (25.5 meters) per second (ANL-E, 1991). In addition, ANL-E facilities are not in the 500-year floodplain. The floodplain areas are largely confined to areas within 200 feet (61 meters) of the surface streams (ANL-E 1993a).

The potable and site water supplies are obtained from groundwater (ANL-E 1993b). The first downstream location where surface water is used for drinking is at Alton, on the Mississippi River, about 370 miles (595 kilometers) from ANL-E. The first downstream location where surface water is used for drinking is at Alton, on the Mississippi River, about 370 miles (595 kilometers) from ANL-E (ANL-E 1993b).

The ANL-E has nine National Pollutant Discharge Elimination System permitted outfalls, most of which discharge directly or indirectly to Sawmill Creek (ANL-E 1991).

In addition to this outfall monitoring, surface water bodies in the region are routinely monitored for radioactive and nonradioactive parameters. In 1990, measurable levels of americium-241, californium-249, californium-252, cesium-137, curium-242, curium-244, neptunium-237, plutonium-238, plutonium-239, strontium-90, and tritium were detected in Sawmill Creek downstream from the only small fraction of the DOE-derived concentration guides for water (DOE Order 5400.5). Dilution in the Des Plaines River reduced the concentration of the measured radionuclides to levels below their respective detection limits. Streams sediments in the ANL-E region are routinely sampled for radionuclides at 3 onsite and 10 offsite locations. These samples are not routinely analyzed for chemical constituents (ANL-E 1991).

Groundwater - The ANL-E vicinity uses two principal aquifers for its water supply. The upper aquifer is the Niagara and Alexandria dolomite, which is about 200 feet (61 meters) thick in the region and has a potentiometric surface between 500 and 100 feet (152 and 30 meters) below ground (ANL-E 1993b). Water flows through this unit in a southern direction (ANL-E 1991). No aquifers in the region are considered sole source aquifers under the Safe Drinking Water Act regulations (EPA 1994).

The ANL-E receives its potable water supply from four wells in the Niagara dolomite aquifer. These wells are approximately 300 feet (91 meters) deep and provide hard water that requires treatment before use (ANL-E 1993b). Treated sanitary and laboratory wastewater from ANL-E are combined and discharged into Sawmill Creek. This effluent averaged 0.83 million gallons (3.1 million liters) per day (ANL-E 1993a).

Groundwater is monitored for radioactive and nonradioactive parameters at 32 ANL-E locations. Groundwater in the four onsite drinking water wells is also monitored for radioactive and nonradioactive parameters, as required by the Safe Drinking Water Act. In 1990, all results were less than the limits established by the Safe Drinking Water Act except for elevated levels of total dissolved solids and turbidity. The average concentration of tritium was approximately 1 percent of the EPA Primary Drinking Water Standard of 20,000 picocuries per liter. One well was removed from service in 1990 (ANL-E 1991).

3.1.4.7 Ecological Resources. The Argonne National Laboratory site lies within the

Prairie Peninsula Section of the Oak-Hickory Forest Region. The Prairie Peninsula is a mosaic of oak forest, oak openings, and tall-grass prairie occurring on glaciated parts of Illinois, northwest Indiana, southern Wisconsin, and parts of other states. Forests in the Argone National Laboratory-East region are predominantly oak hickory. Other forested areas consist of sugar maple, red oak, and basswood (ANL-E 1993a).

The mixture of vegetational communities (open fields, deciduous forests, pine plantations, wetlands, and mowed rights-of-way), coupled with a large degree of protection from human intrusion, makes the Argonne National Laboratory site an effective refuge for many species of animals. These animals are characteristically found in open fields, forests, and forest-edge communities in the Midwest. Also other bird species use the Argonne National Laboratory site as a stopover during spring and fall migrations. By far, the most numerous animals on the site are the small invertebrates (ANL-E 1993b).

The site is inhabited by fallow deer, (Dama dama), eastern cottontail rabbit, opossum, raccoon and squirrels. Although fallow deer have several color varieties, only the white variety occurs at Argonne. Invertebrate fauna consist primarily of dipteran larvae, crayfish, caddisfly larvae, and midge larvae. Few fish are present due to the low summer flows and high temperatures. Wetlands include a cattail marsh and wooded swamp habitat (ANL-E 1993b).

An opinion rendered by the U.S. Fish and Wildlife Service indicated that the only federally listed endangered or threatened vertebrate species likely to be present in the vicinity of the Argonne National Laboratory site is the Indiana bat (Miotis sodalis). An unconfirmed capture of an Indiana bat in nearby waterfall Glen Forest Preserves indicates that the bat may occur on the ANL-E site. In addition, a September 1980 updated of the "Red Book" for the North-Central Region lists the federally endangered bald eagle (Haliaeetus leucocephalus) as wintering in nearby Will County. Both American and Arctic subspecies of the peregrine falcon (Falco peregrinus anatum and F. p. tundrius) and Kirtland's warbler (Dendroica kirtlandii) migrate through northeastern Illinois and thus might occasionally be found on or near the Argonne National Laboratory site. All three of these bird taxa are on the Federal endangered species list (ANL-E 1993b).

At least two plant species proposed for Federal endangered/threatened designation are known to occur in counties near the Argonne National Laboratory site and therefore might be present here. These are Thismia americana, found on wet prairies in Cook County; and Plantago cordata, a plant of wet woodlands recorded in Will County (ANL-E 1993b).

3.1.4.8 Public Health and Safety. The highest annual dose received by an offsite

resident from a combination of the separate airborne and direct exposure pathways from the most recent reports for a 5-year period is presented below (ANL-E 1993a, 1992, 1991, 1990, 1989). The annual doses are only a fraction of the DOE Public Dose Limit of 100 millirem per year. The data are from all laboratory operations, including storage of SNF.

1988	0.66 millirem
1989	0.49 millirem
1990	0.41 millirem
1991	0.29 millirem
1992	0.34 millirem

The total annual population dose to the entire area within a 50-mile (80-kilometer) radius of the laboratory for a 5-year period is presented below (ANL-E 1993a, 1992, 1991, 1990, 1989). The data are from all laboratory operations, including storage of SNF.

1988	25 person-rem
1989	17 person-rem
1990	15 person-rem
1991	15 person-rem
1992	17 person-rem

3.1.4.9 Waste Management. Activities conducted at ANL-E generate a variety of

radioactive and hazardous waste streams (DOE 1994b).

The ANL-E reports 10 mixed waste streams in the inventory of operations waste. Of these, eight are low-level mixed waste streams and two are mixed transuranic waste streams. The ANL-E currently stores about 2.5 cubic yards (1.9 cubic meters) of mixed transuranic waste and projects that 2.1 yards3 (1.6 meters3) of additional transuranic wastes will be generated through the end of 1997. This waste will be processed as necessary (characterized, repackaged, immobilized) to meet the waste acceptance criteria of the Waste Isolation Pilot Plant (DOE 1993e).

The ANL-E has no facilities for treating low-level mixed waste and transuranic waste. ANL-E currently stores about 125 cubic yards (96 meters3) of low-level transuranic waste, which includes low-level waste and transuranic waste reclassified as low-level transuranic waste. Roughly 30 meters3 (39 cubic yards) of low-level transuranic waste are projected to be generated through the end of 1997 (DOE 1993e).

Two major, unused facilities at ANL-E are undergoing environmental restoration. The Laboratory expects to complete removal of the Experimental Boiling Water Reactor vessel by the end of Fiscal Year 1995 and to complete the conversion of the CP-5 reactor building to an interim safe storage condition during Fiscal Year 1994 (DOE 1993f).

3.2 Domestic Research Reactors

The environments of domestic research reactors that may be affected by SNF activities are described in this section. Representative environments of sites generating and storing SNF are described as a basis for assessing the 57 reactor sites identified in Subsection 2.1.2. This approach was selected to permit enveloping the characteristics of the large number of sites covered. Additionally, it is recognized that the programmatic SNF analyses in this EIS are not intended to be site specific. Site-specific environmental information has already been presented to the NRC and analyzed as part of the facility licensing process.

Domestic research reactors are located in a wide variety of environmental settings, ranging from relatively densely populated urban areas to rural/semirural university campuses and industrial parks. To provide reasonably representative descriptions of potentially affected environments for these diverse installations, environmental information has been provided for 5 of the 11 Category 1 reactor sites. These five reactor sites encompass the diverse range of reactor types and power level as well as diverse environmental setting.

As reported in 1988, there were a total of 268 personnel working at the 11 Category 1 reactors (ANS 1988). This number included operators, experimenting scientists, and support personnel. While not their main occupation, part of the duties of the operators and some support personnel include tasks associated with refueling, storing, inventorying, packaging, and shipping SNF.

Environmental information is provided for those facilities whose ability to store SNF is limited when compared to their fuel burnup rate. For those operating facilities possessing adequate storage for their SNF, projected to be generated through 2035, there would be no incremental impacts on the surrounding environment. Accordingly, no environmental analyses have been performed and no information is provided in this section.

The environmental information for each of these reactors has been presented as part of their license applications to the NRC and has been assessed by that agency as part of the licensing process for each facility. The environmental impacts of expanded storage of SNF at these facilities are expected to be minimal (although other effects on the institutions themselves may be extensive). Information on environmental factors that are not affected by the activities of storing SNF at these sites (including cultural resources, aesthetic and scenic resources, ecological resources, noise, traffic and transportation, utilities and energy, materials and waste management) is not provided in this document.

Data on the calculated doses to the general public resulting from effluents from NRC licensed research reactors is not available, since their license and reporting requirements were not the same as those for DOE facilities. At the time of the reports (1987-1993), the effluent release limits in 10 CFR 20 (specified as maximum permissible concentrations) were based on a dose limit of 500 millirem per year to a hypothetical member of the public. The conservative assumptions made in calculating the 10 CFR 20 concentration limits were that the person only drank the water and breathed the air released from the licensed facility. The licensed research reactors proved to the NRC that the dose limit of 500 millirem per year for the general public was being met by maintaining the release concentrations at the site boundary below the maximum permissible concentration limits specified in 10 CFR 20. In reality, the actual dose received by any member of the public was well below the prescribed limit of 500 millirem per year because 1) no individual drinks the water discharged in the sewer systems from these facilities, 2) no individual stands at the closest downwind location for 24 hours a day, 365 days a year, and 3) the radioactivity concentrations at the site boundary are well below the concentration limits.

As of 1993, licensed research reactors are required to meet the dose limits specified by the EPA in 40 CFR 61 of 10 millirem per year to the maximum exposed individual from airborne effluents. In addition, as of 1994, the licensed research reactors are required to comply with the new 10 CFR 20, in which exposure to any member of the public from all pathways is limited to 100 millirem per year.

3.2.1 National Institute of Standards and Technology Research Reactor

The National Institute of Standards and Technology research reactor, formerly known as the National Bureau of Standards Reactor, is a highly enriched, heavy-water-cooled and moderated vessel-type reactor. The National Institute of Standards and Technology reactor received an Atomic Energy Commission provisional license in 1967 to operate at 10 MW. On May 16, 1984, the NRC upgraded the National Institute of Standards and Technology research reactor license to operate for 20 years at up to 20 MW (NRC 1983).

The spent fuel storage pool, located in the basement of the confinement building, is used to store spent fuel under filtered, demineralized water until the fuel is shipped offsite. A spent-fuel storage pool cooling system is installed to dissipate the decay heat from elements stored in the pool. Storage racks are provided to store both full fuel elements and cut fuel pieces in a defined geometry. Boral or stainless steel spacers are placed between elements as required to control criticality. The storage rack arrangement ensures that the fuel in the pool remains subcritical (NRC 1983).

The National Institute of Standards and Technology site is a 576-acre tract of land in upper Montgomery County, Maryland, approximately 1 mile (1.6 kilometers) southwest of the City of Gaithersburg, Maryland. According to the 1990 census, the population of Gaithersburg was 39,542 (Rand 1992). The general area is a combination of residential and rural. The nearest population centers are Gaithersburg, adjacent to the site, and Rockville, 5 miles (8 kilometers) southeast of the site. The National Institute of Standards and Technology site is located approximately 20 miles (32 kilometers) northwest of the center of the District of Columbia. The National Institute of Standards and Technology campus is bounded on the east by a major interstate highway (I-270), on the north and west by Maryland Route 124, and on the southeast by Muddy Branch Road. The area adjacent to the reactor building is occupied by a parking lot, the reactor cooling tower, and roads. Thus, the area within a 500-foot (152-meter) radius of the reactor building stack is not readily available for the construction of new buildings, and planning for future development of the National Institute of Standards and Technology site does not include any new buildings within 500 feet (152 meters) of the reactor stack. The site boundary nearest to the National Institute of Standards and Technology reactor is approximately 0.25 mile (0.4 kilometer) southwest of the reactor. The nearest offsite residential or commercial housing is about 1,500 feet (457 meters) to the southeast of the reactor (NRC 1983).

During the period 1955-1967, 28 tornadoes were reported in a 2 degree latitude-longitude square containing the site. The computed recurrence interval for a tornado at the National Institute of Standards and Technology site is about 2000 years. Numerous tropical storms, tornadoes and hurricanes have affected the area. In the period from 1871 to 1978, about 20 tornadoes or hurricanes have passed within 100 miles (160 kilometers) of the site (NRC 1983).

There is no known major fault in the site vicinity (Seismic Zone 1). There is no known relationship between mapped faults and the moderate seismicity in the region. The maximum potential earthquake for the area was estimated to result in a maximum ground acceleration of 0.07 g at the reactor site. The effects of stresses developed by 0.1 g earthquake loadings have been evaluated, and it was demonstrated that the confinement building and reactor equipment would remain intact and maintain their capability (NRC 1983).

A summary of the radioactive material released in airborne and liquid effluents from the National Institute of Standards and Technology from the most recent reports for a 5-year period is presented below (NIST 1993, 1992, 1991, 1990, 1989).

Year	Airborne effluents		Liquid effluents into sanitary sewer	
	Argon-41	Tritium	Tritium	Other beta-gamma emitters
1988	900 Ci	393 Ci	5.1 Ci	0.0026 Ci
1989	328 Ci	461 Ci	2.9 Ci	0.0039 Ci
1990	687 Ci	309 Ci	2.2 Ci	0.0011 Ci
1991	971 Ci	251 Ci	1.8 Ci	0.0016 Ci
1992	665 Ci	351 Ci	1.5 Ci	0.0004 Ci

3.2.2 Massachusetts Institute of Technology Research Reactor

The Massachusetts Institute of Technology Reactor is a tank-type, light-water cooled and moderated, heavy-water reflected, plate fuel, research and training reactor. The Massachusetts Institute of Technology Reactor received its 5 MW operating license June 9, 1958 and originally was designed to have a heavy-water moderated and cooled core utilizing curved plate-type fuel elements, highly enriched in uranium-235. The major revision of the core design occurred in 1970 (MIT 1981, 1970).

The reactor building is a steel, gas-tight, 70-foot (21.3-meter) internal diameter, 50-foot (15.2-meter) high, domed right cylinder with 2-foot (0.6-meter) thick concrete shielding walls on the inside. The reactor building basement contains an 8-foot (2.4-meter) diameter, 20-foot-deep (6-meter-deep) spent fuel storage tank of demineralized water. The containment building has an air conditioning and multiple filter ventilation system which exhausts to a 150-foot (46-meter) stack.

Irradiated fuel elements can be stored in any of the following locations:

a) In the reactor core
b) In the cadmium-lined fuel storage ring (holds 27 SNF elements) attached to the flow shroud, or briefly in a three-element rack in the core tank used during transfers of spent fuel out of the core tank
c) In 22 steel-lined dry storage holes, 5 inches (13 centimeters) in diameter, on the reactor top biological shield
d) In the spent fuel storage tank in the basement of the reactor building
e) In the fuel element transfer flask or other proper shield within the controlled area.

The Massachusetts Institute of Technology Reactor is located a few blocks northwest of the main Massachusetts Institute of Technology campus in Cambridge, Massachusetts and less than 2,000 feet (610 meters) from the Charles River, which separates Cambridge from Boston. According to the 1990 census, Cambridge had a population of 95,802 (Rand 1992). The MIT Reactor is located in the midst of a heavily industrialized section of Cambridge. The site measures approximately 280 feet in length by 150 feet in width (85 meters by 46 meters). Boston and Albany Railroad tracks, used exclusively for freight traffic, run parallel to the back of the reactor exclusion area. Although the site boundary comes nearest to the reactor on the side facing the railroad tracks, the closest point of normal public occupancy near the site boundary is on the Albany Street side at approximately 120 feet (37 meters). (MIT 1970)

The Massachusetts Institute of Technology Meteorology Department has stated that conditions for the reactor site should vary only slightly from those at Logan Airport in east Boston. The area atmospheric conditions vary from highly stable situations with light winds to unstable periods with strong winds in excess of 47 miles (75.6 kilometers) per hour. Water drainage from the reactor site is into the Charles River and on into Boston Harbor and Massachusetts Bay. The drainage in this section of Cambridge is such that after a record-breaking 20 inches (0.5 meter) of rain fell in 48 hours, the Charles River did not overflow its banks, nor was the area inundated (MIT 1970).

The Cambridge area lies in the Boston Basin which has been relatively free of earthquakes in the past 150 years but had several earthquakes in the preceding centuries. The region is located in Seismic Zone 2. The most severe shock with a probable epicenter near Cambridge occurred in 1755 with a Rossi-Forel intensity of 9 (equivalent to Modified Mercalli Intensity IX or X). Partial or total destruction of some buildings occurred. Since 1817, no earthquake with a Rossi-Forel intensity of more than 5 (equivalent to Modified Mercalli Intensity VI) has been reported near Boston (MIT 1970).

A summary of the radioactive material released in airborne and liquid effluents from the Massachusetts Institute of Technology Research Reactor from the most recent reports for a 5-year period is presented below (MIT 1992, 1991, 1990, 1989, 1988). Liquid radioactive wastes generated at the Massachusetts Institute of Technology Research Reactor facility are discharged only to the sanitary sewer serving the facility. All releases were in accordance with Technical Specifications 3.8-1 and 10 CFR 20. All activities were substantially below the limits specified in 10 CFR 20.303. Gaseous radioactivity is discharged to the atmosphere from the containment building exhaust stack. All gaseous releases were in accordance with the Technical Specifications and all nuclides were below the limits of 10 CFR 20. The information is reported by fiscal year, from July 1 of the previous year to June 30 of the current year.

Year	Airborne effluents	Liquid effluents into sanitary sewer	
	Argon-41	Tritium	Other beta-gamma emitters
1988	2627 Ci	0.071 Ci	0.0011 Ci
1989	1529 Ci	0.107 Ci	0.0034 Ci
1990	543 Ci	0.059 Ci	0.0220 Ci
1991	684 Ci	0.115 Ci	0.0071 Ci
1992	728 Ci	0.023 Ci	0.0137 Ci

3.2.3 University of Missouri/Columbia Research Reactor

The University of Missouri/Columbia Research Reactor is a 10 MW tank in pool light water moderated and cooled research reactor. The reactor uses plate-type fuel containing 93 percent enriched uranium-235. The core forms an annular fuel region which is pressurized and cooled by forced convection. The University of Missouri/Columbia Research Reactor received its operating license October 11, 1966 and initially operated at 5 MW. The reactor power was increased to 10 MW in 1974 (UMC 1965; NRC 1991b).

The reactor is housed in a five-level, poured-concrete, gas-tight containment building which is in the center of the Research Reactor Facility, a one-level building of poured-concrete, block and brick construction. The reactor vessel is located eccentrically within an open pool 10 feet (3 meters) in diameter and 30 feet (9 meters) deep. Permanent SNF storage is provided within the biological shield, in a pool separated from the reactor by a massive submerged concrete weir (UMC 1965).

The University of Missouri/Columbia Research Reactor currently has 44 fuel elements in the core, 20 SNF elements in wet storage and none in dry storage. Without offsite shipment of SNF, the University of Missouri/Columbia Research Reactor's storage capacity of 120 elements would be filled by June 1996. Before this could occur, NRC approval would be required to raise the reactor's uranium-235 possession limit above 165 pounds (75 kilograms). Increased SNF storage capacity could be achieved by reracking and building a new wet-storage area within the reactor building. However, there are no plans to expand the current SNF storage capacity (Jentz 1993).

The University of Missouri/Columbia Research Reactor Facility is located within the 85-acre (0.344-square-kilometer) Research Park about 1 mile (1.6 kilometers) southwest of the main campus of the University of Missouri, south of the main business district of the city of Columbia, Boone County, Missouri. According to the 1990 census, the population of Columbia was 69,101 (Rand 1992). The nearest permanent residence is approximately 1,000 feet (305 meters) from the reactor. There are a number of small industrial activities in the area, but for the county, agriculture is the leading activity.

Wind speeds up to 50 miles (80 kilometers) per hour are not uncommon at Columbia. Ninety-four-mile-per-hour (151-kilometer-per-hour) winds have an average recurrence interval of 100 years; winds of 105 miles (169 kilometers) per hour have an average recurrence interval of

200 years. The frequency of tornadoes is so low that it is difficult to estimate the probability of the event. In most of the Midwest, there are an average 2.5 tornadoes per year in a 10,000 square-mile (25,900-square-kilometer) area. Surface drainage from the site moves south to enter Hinkson Creek, which drains to Perche Creek and then to the Missouri River (UMC 1961).

Columbia's position within the stable area of Missouri (Seismic Zone 1) and the seismic history of the area indicate that the probability of seismic damage to the area is extremely low.

A summary of the radioactive material released in airborne and liquid effluents from the University of Missouri/Columbia Research Reactor from the most recent reports for a 5-year period is presented below (UMC 1992, 1991, 1990, 1989, 1988). The information is reported by fiscal year, from July 1 of the previous year to June 30 of the current year.

Year	Airborne effluents		Liquid effluents into sanitary sewer	
	Argon-41	Tritium	Tritium	Other beta-gamma emitters
1988	813 Ci	14.5 Ci	0.077 Ci	0.0080 Ci
1989	920 Ci	2.8 Ci	0.0352 Ci	0.0085 Ci
1990	590 Ci	2.3 Ci	0.555 Ci	0.0385 Ci
1991	520 Ci	15.0 Ci	0.1600 Ci	0.0250 Ci
1992	440 Ci	0.73 Ci	0.2094 Ci	0.0488 Ci

3.2.4 University of Michigan Ford Nuclear Reactor

The University of Michigan's Ford Nuclear Reactor is a pool-type heterogeneous 2-megawatt-thermal reactor that is light-water cooled and moderated. The Ford Nuclear Reactor has been operated since 1957 and received a 20-year license renewal from the NRC on July 29, 1985 (NRC 1985c). Its principal function is for teaching, research, activation, and experiments (NRC 1985d).

The reactor is located in a windowless, four-story reinforced concrete building that is approximately a 70-foot (21.3-meter) cube. The reactor room, designed to restrict leakage, is equipped with its own ventilation system and exhaust stack (NRC 1985d).

The Ford Nuclear Reactor site situated on the North Campus, which is about 1.75 miles (2.8 kilometers) northeast of the old University of Michigan campus. The North Campus is a tract of nearly 900 acres (3.64 square kilometers), approximately 1.5 miles (2.4 kilometers) northeast of the center of Ann Arbor. According to the 1990 census, the population of the city of Ann Arbor was 109,592 (Rand 1992). The University of Michigan controls all the land within 1500 feet (457 meters) of the reactor site, with the exception of a small portion of the highway right-of-way along Glacier Way to the southeast and the Arborcrest Cemetery, located 800 feet (244 meters) to the east of the site. The reactor exclusion area consists of all the land 500 feet (152 meters) to the east, 1000 feet (305 meters) to the west and north, and 1200 feet (366 meters) to the south (NRC 1985d).

The reactor building and the contiguous Phoenix Memorial Laboratory are located near the center of the North Campus area. The following guidelines were used by the university in developing the North Campus area: (1) only laboratory and research buildings will be constructed within 50 feet (15 meters) of the reactor and (2) no housing or other buildings containing housing facilities will be erected within 1500 feet (457 meters) of the reactor. Therefore, all buildings, except the reactor and laboratory buildings, are generally occupied during normal school hours only. The closest permanent residences are about 1500 feet (457 meters) from the Ford Nuclear Reactor facility (NRC 1985d).

The heaviest rainfall intensity occurs in connection with thundershower activity, and the heaviest recorded 24-hour period of rainfall was approximately 5 inches (13 centimeters). Hourly intensities as high as 1.2 inches (3 centimeters). occur with a frequency of once every 2 years. Average annual snowfall is 30.2 inches (76.7 centimeters.). Annual totals have ranged from 13 to 54 inches (33 to 137 centimeters). The heaviest recorded snowfall for a single day was 6.2 inches (15.7 centimeters). The highest wind velocity recorded in the Ann Arbor area was 60 miles per hour (27 meters per second). Michigan lies at the northeastern edge of the nation's maximum frequency belt for tornadoes. For the past decade, Michigan has averaged nine tornadoes per year, 90 percent of which have been in the southern half of the lower peninsula (NRC 1985d).

The University of Michigan Ann Arbor site, within the Central Stable Region, is characterized by a relatively low level of seismic activity (Seismic Zone 1). Recent interpretations of geophysical investigations suggest that different areas of the Central Stable Region exhibit different levels of seismic activity. For instance, Barstow et al. developed an earthquake frequency map for the eastern United States that places Ann Arbor in a zone where 8-15 earthquakes per 4500 square miles (11,660 square kilometers), with Modified Mercalli Intensities of III or greater, have occurred during the time period 1800-1977. The Anna, Ohio, location experienced a frequency of 32-63 earthquakes per 4500 square miles (11,660 square kilometers) with Modified Mercalli Intensity III or greater for the same time period. The Michigan Basin area, in general, is considered to have had no more than 0-3 earthquakes per 4,500 square miles (11,660 square kilometers) of Modified Mercalli Intensity III or greater. A seismicity map developed by the Geological Survey of the State of Michigan shows that for the time period from 1872-1967, only 34 earthquakes were felt (reported) in the entire State of Michigan. A U.S. Geological Survey seismicity map of the State of Michigan shows a total of 83 earthquakes in the state since 1872. The nearest of these to Ann Arbor (March 13, 1978; Modified Mercalli Intensity IV) was about 30 miles (48 kilometers) away. Only six earthquakes have been reported within 60 miles (96 kilometers) of Ann Arbor. The risk of damage from earthquakes to well-designed structures is relatively low for the Ann Arbor area. In addition, the earthquake intensity/magnitude potential is relatively low for the Michigan region, and there are no known structures in the Ann Arbor area capable of causing earthquakes (NRC 1985d).

A summary of the radioactive material released in airborne and liquid effluents from the Ford Nuclear Reactor from the most recent reports for a 5-year period is presented below (UMI 1994, 1993, 1992, 1991, 1990).

Year	Airborne effluents	Liquid effluents into sanitary sewer	
	Argon-41	Tritium	Other beta-gamma emitters
1989	31 Ci	0.051 Ci	0.18 Ci
1990	35 Ci	0.069 Ci	0.48 Ci
1991	41 Ci	0.079 Ci	0.11 Ci
1992	39 Ci	No discharges	
1993	39 Ci	No discharges	

3.2.5 University of Texas TRIGA

The University of Texas General Atomic TRIGA Mk-II Reactor replaces an earlier TRIGA Mk-I reactor which had been in operation on the main campus in Austin, Texas since 1963. The TRIGA Mk-II is a 1.1 MW heterogeneous, pool-type reactor incorporating solid uranium-zirconium hydride fuel-moderator elements with an enrichment of 19.7 percent uranium-235. The University of Texas TRIGA core is similar to most other TRIGA reactors operated throughout the world as well as the United States. It received its NRC operating license on January 17, 1992 (NRC 1985a, 1992).

The University of Texas TRIGA Mk-II Reactor facility is housed in the Nuclear Engineering Teaching Laboratory on the east tract of the Balcones Research Center about 7 miles (11.3 kilometers) north of the University of Texas main campus, in the City of Austin, Travis County. According to the 1990 census, the City of Austin had a population of 465,622 (Rand 1992). Residential areas are located from 0.8 to 1.3 miles (1.3 to 2.1 kilometers) from the reactor facility. Most areas adjacent to the research center are developed for mixed commercial and industrial activities. Major activities in the area are from the University of Texas main campus at Austin and the State of Texas government and the business district of the City of Austin (NRC 1985a).

Destructive wind and damaging hailstorms are infrequent. On rare occasions, dissipating tropical storms affect the city with strong winds and heavy rains. Tornado activity at the site is roughly one event per year per 1000 square miles (2,600 square kilometers), or 4 x 10-6 per year for an area of 333 square feet (30.8 square meters), which is roughly equal to the general site area. Water drainage at the immediate site is primarily related to the potential but temporary occurrence of extreme rainfall rates. Surface water runoff from the Balcones Research Center site is drained into the Shoal Creek Watershed except for the extreme northeast region of the site, which drains into the Walnut Creek watershed. The facility is located in the northeast site region with drainage into the Walnut Creek watershed. It is situated at an elevation well above the local area flood plain, and is located nearly equidistant 0.5 mile (0.8 kilometer) from the drainage easements of both watersheds. Thus no significant general site area flooding is anticipated (NRC 1985a).

The University of Texas TRIGA reactor site is located in a zone where no damage from earthquakes is expected (Seismic Zone 1). This does not mean, however, that the area is aseismic. The Austin region has experienced three (recorded) earthquakes within a 50-mile (92.6-kilometer) radius since the late nineteenth century:

- May 1, 1873--Manor earthquake with epicentral Modified Mercalli Intensity III-IV
- January 5, 1887--Paige earthquake with epicentral Modified Mercalli Intensity V
- October 9, 1902--Creedmore earthquake with epicentral Modified Mercalli Intensity IV-V.

Other regions in central and east Texas have experienced earthquakes of epicentral Modified Mercalli Intensity V and possibly VI. Damage from an Modified Mercalli Intensity VI earthquake is limited to cracked plaster and damage to chimneys. Structures of good design do not begin to experience damage from intensities below Modified Mercalli Intensity VII. Therefore, when state-of-the-art engineering practices for general structures of common design are adhered to, seismic excitations from earthquakes of Modified Mercalli Intensities V or VI are not expected to affect the integrity of the reactor (NRC 1985a).

The University of Texas TRIGA reactor recently became operational, with its first criticality occurring in March 1992. There is no history of releases and exposures for this reactor.

3.3 Nuclear Power Plant Spent Nuclear Fuel

In this section, the environments of three facilities housing power reactor SNF to be managed by DOE are described. These facilities are the West Valley Demonstration Project in New York State; the Fort St. Vrain SNF Storage Facility in Colorado; and the B&W Research Technology Center in Virginia. General environmental concerns related to these facilities and their operation have been addressed either during their initial licensing/permitting activities or during a subsequent amendment process. Information on environmental factors that are not uniformly available in existing NEPA documentation for all three sites (noise, traffic, utilities and energy, and waste management) are not provided in this document.

3.3.1 West Valley Demonstration Project

The West Valley Demonstration Project consists of numerous structures and facilities. The Fuel Receiving & Storage facility, located adjacent to the original fuel reprocessing plant, is where SNF management activities at the West Valley Demonstration Project are currently performed. The Fuel Receiving & Storage facility consists of the following buildings and systems (WVNS 1993).

- Fuel Receiving & Storage Building - This building contains the spent fuel pool, cask unloading pool, cask decontamination area, cask and fuel handling equipment, and the spent fuel pool water treatment system.
- The water treatment system maintains a water quality that ensures visual clarity for underwater operations and that degradation of the SNF is minimized.
- The spent fuel pool provides shielding from irradiated fuel and ensures that stored assemblies are maintained in a critically safe geometry. The pool is about 30 years old and was not designed with a liner or a leak detection system, nor were the fuel racks designed to withstand a design-basis earthquake.
- Radwaste Process Building - This building houses the equipment for the Radwaste Treatment System, including the high integrity containers used to store spent resins and filter media, as well as shields for those containers.
- Recirculation Ventilation Building - This building houses the ventilation equipment for the Fuel Receiving & Storage building including fans, filters, heaters, chiller, and controls.

The Western New York Nuclear Service Center is located in the town of Ashford, Cattaraugus County, in rural western New York State, approximately 31 miles (50 kilometers) south of Buffalo and 24.5 miles (40 kilometers) inland (east) of Lake Erie. The West Valley Demonstration Project site consists of a 220-acre (88-hectare) tract which is located in the center of the 3,345-acre (1,341-hectare) Western New York Nuclear Service Center, (WVNS 1992a).

3.3.1.1 Land Use. Regional land use is predominantly agricultural, with some scattered

residential areas. The communities of West Valley, Riceville, Ashford, Hollow, and the village of Springville are located within 5 miles (8 kilometers) of the West Valley Demonstration Project. The proximity of the city of Buffalo, Lake Erie, and Lake Ontario influence land use patterns in the region (WVNS 1992a).

3.3.1.2 Socioeconomics. The West Valley Demonstration Project comprises Cattaraugus

and Erie Counties in the State of New York. These counties collectively account for 96 percent of the site's employee residential distribution. Most West Valley Demonstration Project employees live in Erie County. Total employment in the region increased 14.4 percent between 1970 and 1990. During the same period, total population in the region decreased 12.2 percent. Personal income in 1990 for Cattaraugus and Erie County residents was $13,698 and $18,305, respectively (DOC 1992). The total number of housing units within the region is 438,970.

The number of regular employees working at West Valley Demonstration Project is 1050 personnel. Employment associated with SNF management at West Valley amounts to 9 person-years per year (Connors 1995).

3.3.1.3 Cultural Resources. The cultural resources of 360 acres (145 hectares) that may

be affected by future West Valley Demonstration Project Plans and/or West Valley Demonstration Project completion and Western New York Nuclear Service Center closure have been investigated. No recorded extant historic structures are located within or adjacent to the study area, but seven recorded prehistoric sites are within a 1.5-mile (2.4-kilometer) radius of the study area described below. There are no structures or prehistoric sites within the study area nor within the town of Ashford that are listed on the New York State Register of Historic Places or the National Register of Historic Places (WVNS 1994).

3.3.1.4 Aesthetic and Scenic Resources. The natural landscape in the area consists of

rolling wooded hillsides, a mix of actively used agricultural fields, inactive farm fields reverting to brush, and rural homesites. Large portions of the Western New York Nuclear Service Center are relatively undisturbed and consist of a mixture of abandoned agricultural areas in various stages of ecological succession, forested tracts, and wetlands joined by transitional ecotones. The terrain in the area of the Western New York Nuclear Service Center is not unique in terms of landforms, vegetation, expanses of water, or land use (WVNS 1993).

3.3.1.5 Geology. The West Valley Demonstration Project is located within the

Cattaraugus highlands, which is a transitional zone between the Appalachian Plateau Province and the Great Lakes Plain (WVNS 1993).

No fold or fault of any consequence is recognized within the site. The Clarendon-Linden Structure is the closest active "capable" earthquake (fault)-producing feature known to exist in the region. It is approximately 23 miles (37 kilometers) from the site (WVNS 1993). The site has experienced a moderate amount of relatively minor seismic activity. During historical times, ground motion at the site probably has not exceeded a Modified Mercalli Intensity of IV or a horizontal acceleration of 0.05g. It is estimated that the maximum earthquake on the Claredon-Linden Structure would produce an earthquake of Modified Mercalli Intensity of VI to VII and a maximum horizontal acceleration of approximately 0.12g at the site. The Claredon-Linden Fault Zone is located approximately 18 miles (29 kilometers) east of the West Valley Demonstration Project (WVNS 1993).

The West Valley Demonstration Project region has no active volcanoes (Keller 1979). The major soil types at the West Valley Demonstration Project include the well-drained Chenango gravelly loam, the poorly drained Erie silt loam, and the poorly drained Mahoning silt loam.

3.3.1.6 Air Resources. A 200 feet (60-meter) onsite meteorological tower is operated by

DOE at the West Valley Demonstration Project. A review of the West Valley Demonstration Project tower's 1992 data indicates that the prevailing wind was from the south-southeast with a mean wind speed of 5.4 miles per hour (2.4 meters per second). The precipitation for 1992 was 7.1 inches (18 centimeters) above the annual average of 40.9 inches (104 centimeters). The onsite 1992 wind data and National Weather Service wind data collected at Buffalo airport did not compare well, thereby indicating that Buffalo airport is not representative for predicting conditions at the West Valley Demonstration Project.

The state of New York has adopted national ambient air quality standards. The West Valley Demonstration Project is in a Class II Prevention of Significant Deterioration area. The nearest Class I Prevention of Significant Deterioration area is the Edwin B. Forsyth National Wildlife Refuge, approximately 300 miles (483 kilometers) southeast of the site.

3.3.1.7 Water Resources. The West Valley Demonstration Project is located in the

Cattaraugus Creek drainage basin, which is part of the Great Lakes - St. Lawrence watershed. All surface drainage from the West Valley Demonstration Project is to Buttermilk Creek, which flows into Cattaraugus Creek and ultimately into Lake Erie (WVNS 1992a). Cattaraugus Creek is used for swimming, canoeing, and fishing. Although limited irrigation water for nearby golf course greens and tree farms is taken from Cattaraugus Creek, no public water supply is drawn from the creek downstream of the site. The West Valley Demonstration Project has three National Pollutant Discharge Elimination System permitted outfalls that discharge to Erdman Brook (WVNS 1992a).

The West Valley Demonstration Project site has two aquifers, but neither is considered highly permeable. The Cattaraugus Creek Basin aquifer system is a sole source aquifer under Safe Drinking Water Act regulations (EPA 1994). Groundwater beneath the West Valley Demonstration Project is not used for process or drinking water. The site receives all of its water supply from surface water. Offsite water supplies north of the site and south of Cattaraugus Creek derive mainly from springs and shallow dug wells (WVNS 1992a).

More detailed aquifer characterization information can be found in the West Valley Demonstration Project Safety Analysis Report for Project Overview and General Information, WVNS-SAR-001 (WVNS 1993).

3.3.1.8 Ecological Resources. The West Valley Demonstration Project lies within the

Humid Temperature Domain, Warm Continental Division (Bailey 1994). The West Valley Demonstration Project is in a transitional zone between the Appalachian Plateau to the south and east and the Great Lakes Plain to the north and west (WVNS 1992b). The West Valley Demonstration Project is equally divided between forest land and abandoned farm fields (WVNS 1993).

Native vegetation, removed by previous agricultural activity, is becoming reestablished and, if left undisturbed, will slowly revert by successional stages to a climax hardwood community (WVNS 1992b).

Terrestrial wildlife is abundant within the Western New York Nuclear Services Center and surrounding areas because of the mixture of open areas and forested lands as well as the Center's protected nature (WVNS 1992b). Fifty-four species of mammals potentially occur on the site (22 have been recorded onsite). The most common mammal is the white-tailed deer (Odocoileus virginianus), which is also the most abundant game species in the region. However, hunting is prohibited. Other common game and furbearer species include raccoon (Procyon lotor), muskrat (Ondatra zibethica), red fox (Vulpes fulva), gray fox (Urocyon cinereoargenteus), woodchuck (Marmota monax), mink (Mustela vison), beaver (Castor canadensis), eastern cottontail (Sylvilagus floridanus), red squirrel (Tamiasciurus hudsonicus), and gray squirrel (Sciurus carolinensis) WVNS 1992b).

The various old-field, deciduous, and coniferous woodlands, marshes, reservoirs, and streams within the Western New York Nuclear Services Center provide a diversity of habitats used by a wide variety of birds. Bird species at the West Valley Demonstration Project include permanent and summer residents, migrants, and visitants. The abundance of upland meadow ecosystem within the Western New York Nuclear Services Center provides a unique habitat for several New York protected birds (WVNS 1992b).

Aquatic communities at the Western New York Nuclear Services Center include common shiners, eastern blacknose dace, common white sucker, and bluegill sunfish (WVNS 1992b).

Total wetland area is approximately 35 acres (14 hectares). The general types of wetlands on the West Valley Demonstration Project can be described as palustrine, emergent, shrub/scrub, and forested (WVNS 1993a).

A riparian area on Cattaraugus Creek is recognized by New York State as Habitat Significant for Wildlife (WVNS 1992b; WVNS 1993). Canada geese and other waterfowl have been observed periodically using the onsite reservoirs during migration (WVNS 1992b).

3.3.1.9 Transportation. Transportation in the Western New York Nuclear Service

Center vicinity is primarily by highway system. Roads in Cattaraugus County are considered rural roads, except for those in Olean and Salamanca, located 38 miles (61 kilometers) and 26 miles (42 kilometers), respectively, south of the Western New York Nuclear Service Center. New York State classifies rural roads as interstate, principal arterial, minor arterial, major collector, minor collector, and local. Rock Springs Road, next to the Western New York Nuclear Service Center on the west, is a local road that services as the site-access road and connects with U.S. Route 219 about 2.5 miles (4 kilometers) west of the Western New York Nuclear Service Center. Route 219 connects with Interstate 90 (the New York State Thruway) approximately 25 miles (40 kilometers) north and with Interstate 17 (the Southern Tier Expressway) approximately 29 miles (46 kilometers) south of the Western New York Nuclear Service Center (WVNS 1993a).

Rail service to the Western New York Nuclear Service Center is provided by the Buffalo & Pittsburgh Division of the CSX Railroad, located 0.6 mile (1 kilometer) east of the Western New York Nuclear Service Center. A rail spur connects the West Valley Demonstration Project to the CSX (WVNS 1993a).

The Buffalo International Airport is located approximately 31 miles (50 kilometers) north. A general aviation airport, Olean Municipal Airport, is approximately 20 miles (32 kilometers) southeast of the Western New York Nuclear Service Center (WVNS 1993a).

3.3.1.10 Public Health and Safety. Nuclear Fuel Services, Inc. developed an

environmental surveillance program in March 1963 before beginning fuel reprocessing. The program was intended to establish onsite background levels of gross radiological activity in surface water and air. The West Valley Demonstration Project began groundwater monitoring in 1982 (WVNS 1994).

Fallout data show the environmental levels of deposition at West Valley to have been within the nationwide normal range of the Radiation Alert Network measurements. Gross beta measurements in air taken at West Valley also were within the normal range of such readings taken throughout the United States. Levels of airborne particulates and deposition beyond the Western New York Nuclear Service Center perimeter have consistently been indistinguishable from the natural background.

The calculated total dose associated with airborne and liquid effluents released from West Valley Demonstration Project for a 6-year period are presented below (WVNS, 1994). The annual doses for each year are only a fraction of the DOE public dose limit of 100 millirem per year.

Year	Maximum Individual at Site Boundary EDE	Collective Dose Within 50-Miles (80-km)

1988	0.11 millirem	0.031 person-rem
1989	0.08 millirem	0.065 person-rem
1990	0.25 millirem	0.058 person-rem
1991	0.06 millirem	0.015 person-rem
1992	0.05 millirem	0.011 person-rem
1993	0.03 millirem	0.072 person-rem

3.3.2 Fort St. Vrain

Between 1979 and 1989 a high temperature gas-cooled reactor was in operation at the Fort St. Vrain site. In 1989, the Fort St. Vrain reactor was permanently shut down. At that time the Public Services Company of Colorado, the owner of Fort St. Vrain, proceeded with plans to decommission the Fort St. Vrain powerplant. To facilitate the decommissioning, the SNF had to be removed from the reactor. However, implementation of an agreement between the DOE and the Public Services Company of Colorado which would have provided for the storage of Fort St. Vrain SNF at the INEL was blocked, requiring the Public Services Company of Colorado to provide storage for the SNF from the Fort St. Vrain reactor. The SNF from the Fort St. Vrain is being stored in an independent spent fuel storage installation located on the Fort St. Vrain site (FSV 1990b).

The Fort St. Vrain site is located in Weld County in northeastern Colorado, approximately 3.5 miles (5.6 kilometers) northwest of the town of Platteville, 0.5 mile (0.8 kilometer) west of the South Platte River, and 35 miles (56 kilometers) north of Denver. The Fort St. Vrain site consists of 2,798 acres (1,132 hectares). About 1 mile (1.6 kilometers) north of the northern portion of the site is the confluence of the South Platte River and St. Vrain Creek. St. Vrain Creek flows in a northerly direction and passes within approximately 0.75 mile (1.2 kilometers) west of the site at its nearest approach (NRC 1991c; PSC 1994).

3.3.2.1 Land Use. Most of the land in the immediate area of the Fort St. Vrain site is

disturbed, agricultural land. Its agricultural value is enhanced by a number of irrigation ditches fed by surface water diversions from the South Platte River and St. Vrain Creek. The predominant use of the land, surface water, and groundwater is agricultural (NRC 1991c).

3.3.2.2 Socioeconomics. The immediate area surrounding the Fort St. Vrain Nuclear

Generating Station site is rural, with many communities within commuting distance. The nearest community is Platteville. Larger cities in the vicinity include Boulder, Denver, Estes Park, Fort Collins, Greeley, Longmont, Loveland, and Lyons (NRC 1991a).

The population density in the vicinity of the Fort St. Vrain Nuclear Generating Station is low. The nearest residence is more than 2,600 feet (0.8 kilometer) north-northwest of the site. The number of residents living within 1 mile (1.6 kilometer) of the Independent Spent Fuel Storage Installation site (based on projections from 1980 census data) is 39; the projected figure for the year 2012 is 40. However, 1990 figures indicate populations are changing at a similarly low rate, less than 1 percent per year, and consequently the projections will not change significantly (NRC 1991a).

Based on the 1980 census, the population within a 5-mile (8-kilometer) radius of the site at that time was 3,148, with 1,662 residing in the town of Platteville. The projected population for the year 2012 (through the 20-year license) for this same area is 4,526, with 3,040 residing in Platteville (FSV 1990a).

At the present time there are approximately 230 personnel working at the Fort St. Vrain site. Of these approximately 16 full time equivalent personnel work on the Fort St. Vrain SNF storage facility (Holmes 1995).

3.3.2.3 Cultural Resources. There are no known archaeological, cultural, or historical

resources within, adjacent to, or in the immediate vicinity of the Independent Spent Fuel Storage Installation site. The nearest landmarks fitting any of these designations are more than 2 miles (3.2 kilometers) from the site. They include (NRC 1991a):

- The Dent site, an archaeological excavation with mammoth remains left by prehistoric Indians, situated about 4.5 miles (7.2 kilometers) northeast of Fort St. Vrain
- The original Fort St. Vrain, located 2.5 miles (4 kilometers) northeast of the Independent Spent Fuel Storage Installation site
- Fort Vasquez, located 4 miles (6.4 kilometers) southeast of the Independent Spent

Fuel Storage Installation, and listed on the National Register of Historic Places
- Fort Jackson, situated 8 miles (12.8 kilometers) southeast of the Independent Spent Fuel Storage Installation site.

3.3.2.4 Aesthetic and Scenic Resources. The topography at the Independent Spent

Fuel Storage Installation site is flat. It is situated on the high plains, overlooked by the foothills of the Front Range, which rise about 20 miles (32 kilometers) to the west, and by the Front Range crest, which rises to 14,255 feet (4,345 meters) (Longs Peak) about 45 miles (72 kilometers) to the west. The Front Range crest due west of the Independent Spent Fuel Storage Installation site is the most easterly section of the continental divide in the Rocky Mountains. The divide runs along ridges at an altitude of approximately 12,000 feet (3,650 meters) to a high point of 13,327 feet (4,062 meters) (McHenry's Peak) (NRC 1991a).

3.3.2.5 Geology. The Fort St. Vrain site is located on the east flank of the Colorado

Front Range, a complexly faulted anticlinal arch. Numerous faults and smaller folds are superimposed on the arch and are related to the uplift of the Front Range which began in the Late Cretaceous and continued into the Tertiary. In addition to the axes of the superimposed folds, two groups of high angle faults have been recognized: a series of faults along the mountain front that extend in a generally northwest-southeast direction from the Precambrian into the Paleozoic-Mesozoic sediments, and northeast-southwest-oriented faults observed primarily in coal mines located east of Boulder (NRC 1991a).

The Fort St. Vrain site has not experienced any observed earthquake activity (Seismic Zone 1). A field examination and photo interpretation of the area provided no evidence of recent movement along any of the known faults. The closest area of recent activity is about 25 miles (40 kilometers) south of the site. Between April 1962 and May 1967, there were approximately 1,130 earthquake events in this area with magnitudes ranging from 1.0 to 5.0 on the Richter Scale. The 5.0 earthquake produced ground accelerations in the Vrain Valley of 0.002 y 0.001 g. An earthquake with a Modified Mercalli intensity of VII (slight to moderate damage to structures) occurred on November 7, 1882, and was felt throughout Colorado and Southern Wyoming. Due to the sparse population in the epicentral region, the assigned intensity may in actuality be an underestimate. A reasonable guess for its Richter magnitude is 6.5, implying that most of the strain energy released by earthquakes of Colorado in the last century was released in this one earthquake (NRC 1991a).

3.3.2.6 Air Resources. The general climate around the Fort St. Vrain site is typical of

the Colorado eastern-slope plains region. The weather is generally mild. Most seasons are characterized by low humidity and sunny days, with occasional brief storms bringing precipitation to the area. Thermal radiation losses resulting from lack of cloud cover provide considerable variation in temperature from night to day. In this semiarid region, the precipitation averages 10 to 15 inches (25 to 38 centimeters) a year, mostly from thunderstorms in late spring and summer. Snowfall is significant; however, the snow cover is usually melted in a few days. Relative humidity averages about 40 percent during the day and 65 percent at night (NRC 1991a).

Meteorological conditions in the local area include a preponderance of stable meteorological conditions and rather low wind speeds. Wind speeds generally range from 1 to 7 miles per hour (0.45 to 3.2 meters per second) 80 percent of the time. Wind directions are rather evenly distributed, although there is a preponderance of winds from the southwest and northeast quadrants. Seasonally, winds tend to be strongest in the late winter and spring, the season with high chinook frequency, and again in the summer, when thunderstorms occur frequently. Strong winds, especially under chinook conditions, have been observed on various occasions in easter Colorado. The chinook winds are strongest immediately to the east of the mountain ridge and diminish rapidly over the plains with increasing distance from the mountains (NRC 1991a).

The region typically experiences five tornadoes per year per 10,000 square miles (25,900 square kilometers), with peak tornado activity occurring during the month of June. According to the National Weather Service, Weld County has had 117 tornadoes during the period 1950-1987. A study of tornadoes in the area concluded that 100 mile (160 kilometer) per hour winds should constitute maximum forces to be expected at Fort St. Vrain (NRC 1991a).

Northeastern Colorado has moderate thunderstorm activity. The region near Fort St. Vrain averages 50 days a year in which thunder and lightning occur. The majority of these thunderstorms are present from late spring through the summer (NRC 1991a).

3.3.2.7 Water Resources. The topography in the immediate vicinity of the site is

relatively flat and water use is primarily agricultural. Its distribution is through the use of irrigation ditches. The nearest major surface water features are the South Platte River, about 0.5 mile (0.8 kilometer) east of the site, and the St. Vrain Creek, about 0.75 mile (1.2 kilometers) west of the site. Local surface water diversions from these rivers, which feed irrigation ditches to support agriculture, are somewhat closer, about 0.33 mile (0.5 kilometer) east and west of the site, and about 0.4 mile (0.64 kilometer) to the north. The net local topography, which controls the direction of surface runoff, slopes slightly to the northeast toward the South Platte River. This trend is interrupted by the irrigation ditches. There are no liquid discharges from the dry storage facility (NRC 1991a).

3.3.2.8 Ecological Resources. Wildlife indigenous to the area include several species of

ducks and geese, the mourning dove, cottontail rabbit, fox squirrel, and to a lesser extent bobwhite quail, ring-necked pheasant, deer, and antelope. The most abundant fish species include the white sucker, carp, notropis, creek chub, and, to a lesser extent, several types of perch (NRC 1991a).

With most of the land dominated by agriculture, natural vegetation is minimal. Most of the trees found along roads, in hedgerows, and around farm houses are cottonwood. Trees found in the river area are primarily cottonwoods, willows, and Russian olives. Typical grasses and weeds found in river bottom areas include gnat heads, golden weed, snake weed, Smith grass, Indian grass, foxtail and big bluestem. The site does not have readily visible evidence of recent farming but is now overrun with plants which are typically indigenous to disturbed land; plant species include Russian thistle, cocklebur, Canada thistle, dandelion, and poor-man's pepper grass (NRC 1991a).

The only threatened or endangered animal species known to occur within the area of the project are the bald eagle and the peregrine falcon. However, this land has not been identified as a critical habitat for these or any other species. The black-footed ferret, also endangered, may be found as a transient within the region, but requires a permanent habitat which is occupied by prairie dogs. Prairie dogs are not present at the site (NRC 1991a).

3.3.2.9 Transportation. There are no airports within the immediate vicinity of the

Independent Spent Fuel Storage Installation site. Stapleton International is about 30 miles (48 kilometers) south of the site. County roads with their associated rights-of-way are adjacent the exclusion area boundary or provide access to the generating station (County Roads 21, and 19 1/2, respectively). A railroad spur connects the site to the Union Pacific Railroad main line located about 2 miles (3.2 kilometers) to the west (NRC 1991a).

3.3.2.10 Public Health and Safety. Results from an Independent Spent Fuel Storage

Installation Site Background Radiation Study, completed by Colorado State University in October 1990, including the mean integral exposure rate of 0.34 mR per day, were consistent with data acquired for the area during previous years of sampling by the Fort St. Vrain Radiological Environmental Monitoring Program. With the exception of cesium-137, whose average surface activity concentration of 0.18 pCi/g is consistent with regional levels due to global fallout, no statistically significant concentrations of activation or fission products were detected (NRC 1991a).

The design of the modular vault dry store system is such that its operation does not result in any water or other liquid discharges, generate any chemical, sanitary, or solid wastes, or release any radioactive materials in solid, gaseous, or liquid form during normal operations. The primary radiological exposure pathway associated with the Independent Spent Fuel Storage Installation operation is direct irradiation of nearby residents and site workers. The highest dose to the nearest resident for any year is about 0.1 mrem. The highest collective dose commitment for any year to the population within 5 miles (8 kilometers) of the Independent Spent Fuel Storage Installation will not exceed 0.45 person-rem (NRC 1991a).

3.3.3 B&W Lynchburg

B&W Lynchburg maintains a large nuclear fuels research facility at its Mount Athos site. This site is about 925 acres (374 hectares) in area with the research facility within a 4-acre (1.6-hectare) fenced area. Numerous support facilities are located outside and adjacent to this fenced area. The research facility is in Campbell County, Virginia near the James River, approximately 4 miles (6.4 kilometers) east of the city of Lynchburg (NRC 1987).

Building A was constructed in 1956 and housed the Lynchburg pool reactor and the Critical Experiment Facility. This facility has been decommissioned (NRC 1987).

Building B contains a hot cell facility with its associated operations area, cask handling area, transfer canal and storage pool, and various laboratories associated with the examination of radioactive materials. It also houses a demineralizer for the cleanup of the pool water (NRC 1987).

Building C was used as a plutonium fuels development laboratory and for research and development of processes for other nuclear fuels. It is undergoing decommissioning (NRC 1987).

Building J and its Annex are used for solid waste storage. High, intermediate, and low-level wastes may be stored here. Irradiated fuel wastes are being stored until they are accepted by the DOE in accordance with the provisions in the Nuclear Waste Policy Act of 1982 (NRC 1987).

3.3.3.1 Land Use. Land use in Campbell and Amherst counties is dominated by farming

and forestry. Although the site lies in an agricultural region, very few of the important agricultural characteristics attributed to the region occur within 5 miles (8 kilometers) of the site because of unfavorable terrain. The region is characterized by mixed land use consisting of small areas of farmland (crop and pasture) interspersed within large tracts of forested area (NRC 1986).

3.3.3.2 Socioeconomics. The Lynchburg Research Center and the nearby City of

Lynchburg are centrally located within the area of Amherst, Appomattox, Bedford, and Campbell counties. The combined population of these counties and Lynchburg is about 180,000 (NRC 1986).

The Lynchburg area's commercial and industrial interests provide a large percentage of the employment in the four-county area. Although farming and forestry activities dominate the land use in the region, they provide less than 1 percent of the economic activity and very little permanent employment. Other principal commercial, industrial, and population centers that may influence the four-county area or may be slightly influenced by B&W operations are Roanoke, Charlottesville, Richmond, and Danville (NRC 1986).

The Lynchburg Research Center has about 180 employees, and the other facilities on the B&W site employ about 2,200. The total employment on the B&W site is only about 3 percent of the 69,000 persons employed in the Lynchburg Standard Metropolitan Statistical Area. The B&W operation is an important, although not critical, source of employment in the Lynchburg region (NRC 1986).

3.3.3.3 Cultural Resources. A review of the Federal Register reveals that the only historic

site on the National Register of Historic Places located within 5 miles (8 kilometers) of the B&W facilities is the 19th-century Mt. Athos Plantation, which is across the road to the east of the site. There are numerous historic places between 5 and 25 miles (8 kilometers and 40 kilometers) from the B&W site, particularly in Bedford County and Lynchburg to the west. The best known historic site is the Appomattox Court House National Historic Park, about 15 miles (24 kilometers) to the east (NRC 1986).

3.3.3.4 Aesthetic and Scenic Resources. The topography of the plant site is generally

rolling with gentle slopes. The nominal river elevation is 470 feet (143 meters) above mean sea level. The dominant topographic feature of the site is a hill located approximately at the center of the property, the crest of which rises to 693 feet (211 meters) above mean sea level. The site includes a large area of relatively flat floodplain adjacent to the river. The highest point in the vicinity of the site is the top of Mt. Athos, where the elevation is 890 feet (271 meters) above mean sea level (NRC 1986).

3.3.3.5 Geology. The James River Basin of Virginia includes portions of four

physiographic provinces characterized by distinct land forms and physical features. These provinces, located west to east, are Valley and Ridge, Blue Ridge, Piedmont, and Coastal Plain. Western or inner Piedmont, where the B&W property lies, is an upland characterized by scattered hills, some of mountainous dimensions, lying eastward from the foot of the Blue Ridge (NRC 1986).

No important mineral resources have been identified at the B&W site, and U.S. Geological Survey topographic maps do not indicate any significant surface or underground mining activities within 5 miles (8 kilometers) of the site (NRC 1986).

The B&W site is located in a western part of the central Virginia cluster region which is classified as Zone 2 on the Seismic Risk Map of the United States. This zone corresponds to an intensity of VII according to the Modified Mercalli scale, which implies building damages to the extent of fallen chimneys and cracked walls. During the period 1758 through 1968, 121 earthquakes with epicenters in Virginia were reported. The largest earthquake was in 1897, with a probable epicenter in Giles County, approximately 100 miles (160 kilometers) west of the plant site. A maximum intensity of VIII was estimated in the epicentral region, but an intensity of only V-VI was estimated at the plant site. The second largest earthquake was in 1875, with a maximum epicentral intensity of VII more than 50 miles (80 kilometers) east or northeast of the site. The estimated intensity at the site was V. No other quakes have been recorded with intensities at the site greater than the 1875 or 1897 occurrences (NRC 1986).

3.3.3.6 Air Resources. The climate of the Lynchburg area is influenced by cold and dry

polar continental air masses in the winter and warm and humid gulf maritime air masses in the summer. Extremes in weather conditions in the area are rare. The mean temperature is about 56.7oF (13.7oC), with normal average temperatures ranging from 76.3oF (24.6oC) in July to 38.5oF (3.6oC) in December. Rainfall amounts at Lynchburg can be expected to reach 40.3 inches (102.4 centimeters) in any given year. The monthly rates are nearly uniform except for a slightly higher rate during the summer months. Snowfall in the Lynchburg area generally occurs between the months of December and March. The mean yearly snowfall total is 19.4 inches (49.3 centimeters). Winds at Lynchburg are predominant from the southwest with a mean speed of 8 miles per hour (3.6 meters per second). Mean relative humidity values in Lynchburg at 7:00 am, 1:00 pm, and 7:00 pm are 78, 51, and 62 percent, respectively. Heavy fog (visibility of less than 1,320 feet or 400 meters) can be expected to occur at the site on the average of 40 days per year (NRC 1986).

Severe weather at the Lynchburg Research Center is generally limited to thunderstorms, with a low probability of tornadoes. Climatological data show that the mean number of thunderstorms occurring at Lynchburg is 22 per year. According to methods for estimating tornado occurrence presented by Thom, the probability of a tornado's actually striking the site is 3.0 x 10-4 per year, with a recurrence interval of 3,333 years (NRC 1986).

The B&W Lynchburg Research Center is located in the Central Virginia Air Quality Control Region, where the air is classified by the Environmental Protection Agency as "better than national standards" for total suspended particulates and sulfur dioxide. The City of Lynchburg also meets the national standards for total suspended particulates and sulfur dioxide. For carbon monoxide, nitrogen dioxide, ozone, and hydrocarbons, the Air Quality Control Region cannot be classified because data are not available (NRC 1986).

3.3.3.7 Water Resources. A relatively large forested floodplain exists between the

normal elevation of the James River and the estimated highest flood state at the site. Since no Lynchburg Research Center structures are located in the floodplain, plant operation does not impact floodplain features (NRC 1986).

The James River is formed about 96 miles (154 kilometers) upstream of the site by the confluence of the Jackson and Cowpasture Rivers. The James River flows generally south-southeast from the Valley and Ridge Province to the Atlantic Ocean through the Hampton Roads and Chesapeake Bay. On the basis of records for two U.S. Geological Survey gaging stations, one about 20 miles (32 kilometers) upstream and the other about 21 miles (34 kilometers) downstream of the site, the annual average flow rate of the river at the plant is estimated to be about 3900 cubic feet per second (110 cubic meters per second). The estimated water surface elevation at the site at the average flow rate is approximately 470 feet (143 meters) above mean sea level (NRC 1986).

Eleven great floods of the James River occurred at the plant site in 1771, 1795, 1870, 1877, 1889, 1913, 1930, 1936, 1969, 1972, and 1985. The 1795 flood had the highest flood state, which was 535 feet or 163 meters above mean sea level at Lynchburg and 494 feet (151 meters) above mean sea level at the site (estimated). The largest recent flood occurred in November 1985 and had a flood state of 534 feet (163 meters) above mean sea level at Lynchburg (NRC 1986).

The Standard Project Flood determined by the U.S. Army Corps of Engineers for the James River would produce a discharge rate of 10,705 m3/S (378,000 cfs) and a flood state of 502 feet (153 meters) above mean sea level at the site (NRC 1986).

Because the elevation of the plant floors at the Lynchburg Research Center is 589 feet

(180 meters) above mean sea level, which is 95 feet (29 meters) above the maximum historical flood state or 37 feet (26 meters) above the Standard Project Flood elevation, James River floods would not affect the research and development facility at the Lynchburg Research Center (NRC 1986).

Measurements in potable wells located in the river floodplain near the B&W Commercial Nuclear Fuel Plant in the northeast corner of the site indicate that the groundwater elevation ranges between 440 and 460 feet (134 and 140 meters) above mean sea level, which is 10 feet (3 meters) below surface elevation at the annual average flow rate. Because of the relative impermeability of the silt and clay topsoils, neither the water in surface soils nor river flood water has a major effect on the groundwater supply or quality. B&W obtains about 100,000 gallons per day (380 cubic meters per day) from the above-mentioned wells for drinking and industrial uses. An average of 19,300 gallons per day (73 cubic meters per day) is used at the Lynchburg Research Center. Continuous pumping tests on these wells indicates a plentiful supply of groundwater. Therefore, it is not likely that the performance at nearby residential wells would be affected by B&W's operations (NRC 1986).

3.3.3.8 Ecological Resources. Natural climax vegetation in the region is classified as

oak-hickory-pine (Quercus-Caray-pinus) forest. Dominants include white (Q. alba), post oak (Q. stellata), hickory (Carya spp.), shortleaf pine (P. echinata) and loblolly pine (P. toeda). Other common species include tulip poplar (Liriodendron tulipifera), sweetgum (Liquidambar styraciflua), dogwood (Cornus florida), and several other species of oak, hickory, and pine (NRC 1986).

The great diversity of plants and vegetative communities in the site vicinity provide a wide variety of habitats for wildlife. There are approximately 24 species of mammals, 160 species of birds, 19 species of reptiles, and 17 species of amphibians expected to occur in the Lynchburg area. Species in the vicinity of the site that are economically important include game mammals, e.g., white-tailed deer (Odocoileus virginianus) and black bear (Ursus americanus), otter (Lutra canadensis), red fox (Vulpes vulpes), and beaver (Castor canadensis); and mourning dove (Zenaida macroura) and several species of water fowl (NRC 1986).

The aquatic biota of the James River in the vicinity of the Lynchburg Research Center is generally characteristic of that of a moderately polluted river. Examination of photoplankton communities downstream of the site at Cartersville shows reasonably diverse communities consisting of green, yellow-green (diatoms) and blue-green algae during the late summer. Phytoplankton communities during the fall, winter, and early summer consisted almost entirely of a few species of yellow-green algae (NRC 1986).

Most of the fish in the James River in the vicinity of the Lynchburg Research Center are primarily members of the minnow, sucker, sunfish, perch, and catfish families. Species in these families range from common to uncommon. There is no commercial fishery in the vicinity of the Lynchburg Research Center site (NRC 1986).

Federally and state-listed threatened and endangered animal species whose present or former geographic ranges include central Virginia and the B&W site are the bald eagle (Haliaeetus leucocephalus), American peregrine falcon (Falco peregrinus), gray bat (Myotis grisescens), Indiana bat (Myotis sodalis), Virginia big-eared bat (Plecotus townsendii virginianus), and eastern cougar (Felis concolor couguar). There have been no reports of these species being observed on the site or its vicinity (NRC 1986).

There are no species of rare or endangered fish or mollusks known to occur in the James River in the vicinity of the site (NRC 1986).

3.3.3.9 Transportation. The site is bounded on three sides by the James River and on

the fourth side by Virginia State Route 726. The site is serviced by a spur of the CSX Railroad, which runs through the B&W property. The site is also conveniently located for truck and automobile access, because only about 2 miles (3.2 kilometers) from the plant, State Route 726 connects with U.S. Highway 460, a major link between Roanoke and Richmond (NRC 1986).

3.3.3.10 Public Health and Safety. The total-body dose rate for the vicinity of

Lynchburg is approximately 107 millirem per year. This dose rate includes 43 millirem per year from cosmic rays, 45.6 millirem per year from terrestrial sources, and 18 millirem per year from internal emitters (NRC 1986).

4. ENVIRONMENTAL CONSEQUENCES OF SPENT NUCLEAR

FUEL MANAGEMENT ACTIVITIES

This section presents the projected impacts of implementing the programmatic alternatives for management of SNF for which DOE has accepted present or future responsibility. The SNF management activities evaluated in this section only include those actions identified by the originating sites to be implemented should the No Action Alternative be adopted, as described in Section 2. SNF management activities planned independently of this EIS are addressed only if they are directly affected or altered as a result of the programmatic SNF alternatives considered in this EIS. Only Alternative 1, No Action, has any potential for affecting some of the facilities addressed in this Appendix. Thus only the environmental consequences of SNF management activities at originating sites under Alternative 1 will be discussed here. For the other DOE alternatives, the environmental consequences of SNF transportation from originating sites are analyzed in Appendix I to Volume 1. The environmental consequences at the DOE facilities that receive the SNF originating from any facilities in this Appendix are addressed in Appendixes A, B, C and F.

4.1 No Action

4.1.1 DOE Experimental Reactors and Small-Quantity Storage

The DOE's reactors at the Brookhaven National Laboratory, Los Alamos National Laboratory, and Sandia National Laboratories would not be affected by the No Action Alternative through the year 2005. Between 2006 and 2035, however, implementation of this alternative might require modifications of SNF management activities at the reactor facilities.

4.1.1.1 Brookhaven National Laboratory. The High Flux Beam Reactor at the

Brookhaven National Laboratory is planned to continue to operate for the foreseeable future. The presently planned installation of a storage rack in the existing wet storage facility, providing 162 additional storage locations, will be depleted in 1998. It is expected that the arrangement of the existing racks will be modified to provide additional storage capacity in the existing pool if SNF cannot be shipped at that time (Carelli 1993).

Fuel storage capacities at the Brookhaven National Laboratory High Flux Beam Reactor would be severely taxed if the No Action Alternative were selected. Selection of the No Action Alternative could result in the eventual shutdown of the High Flux Beam Reactor as a result of filling the existing SNF storage capacity. Implementation of the No Action Alternative would be expected to have no operational impact on the Brookhaven Medical Research Reactor (Carelli 1993).

There is no safety analysis or technical specification limit on the number of elements stored, so the proposed addition of a new storage rack should be accompanied by a new criticality analysis (DOE 1993c).

The fuel canal is unlined and there is no continuous and accurate way of measuring leak detection. However, alarms for high and low water level are in the control room and the water level is regularly monitored. Records are maintained for canal water additions, and thus any increased amounts of canal makeup water can be detected. The canal has been sealed against evaporation about every 5 years to measure leakage, and no leakage problems have ever been detected. Also, there are groundwater monitoring wells near the High Flux Beam Reactor that are sampled twice per year, and no significant amounts of radionuclides have ever been detected. No known damaged fuel is presently stored in the fuel canal (DOE 1993c).

The fuel canal water monitoring program is adequate to control corrosion and to minimize the release of fission products. In addition, corrosion surveillance coupon samples have been photographed and evaluated yearly since stored in the canal in 1977. These photographs have shown no corrosion damage (DOE 1993c).

In view of the absence of any substantive difference in SNF management operations attributable to the No Action Alternative, effluent releases and their associated doses would be expected to be the same as those currently being experienced there.

Potential impacts on the Nassau/Suffolk Aquifer System as a result of SNF management alternatives described in this EIS are expected to be small. If the fuel canal were to leak, ground water impacts would be expected, but monitoring measures would mitigate impacts by permitting early detection of leaks.

For the Brookhaven Medical Research Reactor, which has sufficient SNF storage capacity, the No Action Alternative would cause no environmental consequences--other than those that have already been addressed and accepted under the siting and operation approval process.

4.1.1.2 Los Alamos National Laboratory. The Omega West Reactor at Los Alamos

National Laboratory is permanently shut down. It is being decommissioned. The SNF is in temporary storage at the Chemistry and Metallurgy Research complex. Although at present the stored fuel elements do not present a health or safety hazard, storage of fuel at the Chemistry and Metallurgy Research complex presents a potential radiological hazard at that facility. The Los Alamos National Laboratory does not have the capability to store, handle or monitor spent fuel for any extended length of time. The Rover casks contain no monitoring devices, and storage of spent fuel is not addressed in the current Chemistry and Metallurgy Research complex authorization. It is recommended that the fuel be relocated as soon as practical.

For the other Los Alamos National Laboratory facilities that have sufficient SNF storage capacity, the No Action Alternative would cause no environmental consequences--other than those that have already been addressed and accepted under the siting and operation approval process.

4.1.1.3 Sandia National Laboratories. Each of the reactors at Sandia National

Laboratories is designed so that the uranium fuel source essentially lasts the designed life of the reactor. Consequently, none of the reactors require periodic refueling or discharge spent fuel. Therefore, the No Action Alternative would cause no environmental consequences--other than those that have already been addressed and accepted under the siting and operational approval process for these facilities at Sandia National Laboratories (DOE 1993d).

4.1.1.4 Argonne National Laboratory - East. Essentially all of the SNF at the Argonne

National Laboratory site in Illinois is contained in the Alpha-Gamma Hot Cell Facility. The Alpha-Gamma Hot Cell Facility is an operating hot cell where fuel development programs have been conducted for 29 years. The SNF located there is a combination of material in process and the stored residues from past programs (DOE 1993d).

The condition of the stored SNF is generally good and would be an issue only if its physical and chemical state dictates that it must be treated before it will be acceptable at a long-term interim storage site or a final repository. Likewise, the physical condition of the facility is good, considering its 29-year age. The SNF is contained within the hot cell, which precludes its entry into the environment except under the most extremely low-probability events (DOE 1993d).

4.1.2 Domestic Research Reactors

In Section 2.2.1.2, it was noted that SNF storage facilities at 34 domestic research reactors would not be overloaded were the No Action Alternative (i.e., no off-site SNF transportation) to be implemented. For those sites, the adoption of the No Action Alternative would produce no incremental impacts on the environment.

This conclusion is supported by NRC determinations in a number of licensing actions related to requested increases in possession limits for U-235 in fuel at research reactor sites. In these licensing actions, the NRC has determined that there is no significant impact on the environment from normal operation or accidents associated with the increases in the possession limits for U-235 at those reactor sites. The possession or storage of fuel at the domestic research reactor sites is not considered by the NRC to be a significant activity as indicated by the following examples of their findings.

In 1993, the NRC performed a safety evaluation in response to the University of Missouri at Columbia request for a temporary increase in the license possession limit for U-235 from 45 to 60 kilograms. In regard to potential accidents the NRC determined: "There are no specific accidents in this type of research reactor associated with the storage of spent fuel in accordance with the Technical Specifications. The maximum hypothetical accident of complete fission product release of four fuel plates in the reactor core is not affected by increasing the amount of stored fuel. Because the fuel will be stored in accordance with the Technical Specifications, accidents previously evaluated are not changed and no new or different kind of accident is created. Therefore, the staff concludes that the temporary increase in the possession limit of U-235 is acceptable."

In regard to environmental considerations of this possession increase, the NRC stated: "The staff has determined that the amendment involves no significant increase in the amounts, and no significant change in the types, of any effluents that may be released offsite, and there is no significant increase in individual or cumulative occupational radiation exposure. Accordingly, this

amendment meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9).
Pursuant to 10 CFR 51.22(b), no Environmental Impact Statement or Environmental Assessment need be prepared in connection with the issuance of this amendment." (NRC 1993b)

In 1991, in performing a safety evaluation in response to an earlier University of Missouri request for a temporary increase in the license possession limit for a larger amount of U-235 from 60 to 75 kilograms, the NRC reached the same determinations and conclusions as in the 1993 licensing action. (NRC 1991b)

In response to the request from the Massachusetts Institute of Technology request in 1991 to extend a temporary increase in the possession limit of U-235 of 41 kilograms until January 1, 1994, the NRC performed an evaluation and made identically the same determination as that quoted above for the University of Missouri license amendment. (NRC 1991d)

The NRC, in its Environmental Assessment for the Training and Research Reactor of the University of Lowell, stated: "Accidents ranging from the failure of experiments up to the largest core damage and fission product release considered possible result in doses that are less than 10 CFR Part 20 guidelines and are considered negligible with respect to the environment.... The staff concludes that there will be no significant environmental impact associated with the licensing of research reactors or critical facilities designed to operate at power levels of 2 MWt or lower and that no environmental impact statements are required to be written for the issuance of construction permits or operating licenses for such facilities." (NRC 1985b)

In the Environmental Impact Statement for the University of Texas, TRIGA Mark II reactor, it was stated: "Storage, processing and disposal of fuel elements is not considered a significant activity of this facility." (NRC 1984)

Of the 11 domestic research reactors that are projected to exhaust their storage capacity, a few facilities indicated that they might take measures to physically expand their SNF storage capacity within their existing structures beyond what had been planned. Only one facility has indicated that it might elect to create an 18.6-square-meter (200-square-foot) storage area outside the existing structure. An addition of this small size would be expected to have a minuscule impact on the previously disturbed environment.

A small number of these facilities could request deferral of their directed conversion from highly enriched uranium fuel to low enriched uranium fuel. The environmental consequences of such an action would derive from extending the risks of theft or diversion of highly enriched uranium fuel which the U.S. Government has tried to reduce by mandating the conversion (Jentz 1993).

An unidentified number of the research reactors may elect to discontinue operation at some time during the next 40 years. Storage of the SNF onsite at a reactor facility that is undergoing decommissioning would interfere with the radiological surveys conducted to ensure that the reactor site is returned to the pristine conditions that existed before the reactor was constructed.

The consequences of premature shutdown of any of these reactors, attributable to implementation of the No Action Alternative, would include the loss of service which the reactors were scheduled to provide. These consequences of implementing the No Action Alternative could include, for example:

- Loss of education and training for some nuclear engineers and scientists
- Loss of trace analysis capability supporting solar cell material research, monitoring of atmospheric pollutants, detection of trace metals in foods, and analysis of criminal artifacts
- Loss of specific materials research capability relating to hydrogen in metals, metglasses, amorphous magnetic materials, and biomolecular polymers
- Loss of specific nuclear medicine and radiation therapy.

Any changes in radioactive (or other) releases or exposures to the public or to workers would be inconsequential. More detailed analyses of radiation exposures and other impacts would be provided in site-specific NRC licensing documents before implementation of any changes in these facilities that were made necessary by an SNF transportation moratorium.

4.1.3 Nuclear Power Plant Spent Nuclear Fuel

4.1.3.1 West Valley Demonstration Project. It has been determined that continued use

of the SNF storage pool in the Fuel Receiving & Storage building at the West Valley Demonstration Project is not a viable option for extended periods of time. Therefore, alternative concepts for storing West Valley Demonstration Project SNF are being evaluated by the Project. The options being considered at West Valley include dry storage, wet storage involving refurbishing of a portion of the existing spent fuel storage pool, and continued use of the present facility.

Dry storage is projected to require a maximum area of 0.003 square kilometer (0.72 acre) (i.e., a square plot of land about 54 meters [177 feet] on each side). This area would include the actual storage facility, approach pads, and perimeter fence. The largest base pad required for any of the dry storage concepts would measure 9.1 by 15.2 meters (30 by 50 feet) and be between 0.61 and 1.22 meters (2 and 4 feet) thick (WVDP 1993).

The wet storage concept and No Action Alternative assume the continued use (either modified or as is) of the existing spent fuel storage pool. These options should have no measurable impact on the West Valley Demonstration Project site. The actions taken to transfer the spent fuel from the storage pool to the on-site dry storage facilities would not differ from those taken to transfer this SNF to the INEL or any other DOE facility. Therefore, there would be no additional environmental impact resulting from these fuel transfer activities.

Potential impacts on the Cattaraugus Creek Basin Aquifer System as a result of SNF Management alternatives described in this EIS are expected to be small.

Keeping the SNF in dry storage on-site would result in both on-site and off-site exposures that would not occur if the fuel were shipped off-site once it was removed from the storage pool. Storing the fuel dry in sealed containers would not result in the production of radioactive liquid or gaseous effluents or solid radioactive wastes. The source of the on-site and off-site radiation doses is direct radiation from the dry spent fuel storage facility. Estimates have not yet been developed for these doses, because a storage concept has not been selected.

The 125 fuel assemblies in the Fuel Receiving and Storage Facility have been in storage for over 20 years. Their total heat generation rate is less than 9 kilowatt and fission product inventory should have reached a near steady state condition. Conservative calculations in safety analysis report estimate that failure of all 125 fuel assemblies would result in an off-site dose of 42 mrem and an on-site dose of 2.1 rem (DOE 1993c).

Doses and solid waste generation volumes resulting from implementation of the No Action Alternative would remain the same as the current operation at the West Valley Demonstration Project. The calculated annual effective dose equivalent resulting from the total site operations including wet storage of SNF at the West Valley Demonstration Project are as follows: (WVNS 1994)

Maximum individual off-site dose from gaseous releases	1.6 x 10-4 mrem/year
Maximum individual off-site dose from liquid releases	1.1 x 10-2 mrem/year

4.1.3.2 Fort St. Vrain. The Fort St. Vrain facility has already constructed an Independent Spent Fuel Storage Installation for interim storage (with a 40 year design basis) of the SNF from the Fort St. Vrain power plant. Onsite storage will have no additional impact on the Fort St. Vrain site (FSV 1990a). However, under this alternative, Public Service Company of Colorado would not achieve its goal of becoming free of radioactive materials by 1998 under this option.

4.1.3.3 B&W Lynchburg Technology Center. The Lynchburg Technology Center received the SNF between 1980 and 1987 as part of a "high-burnup" research program sponsored by the DOE Office of Nuclear Energy. The experiments were completed in 1989 and the program was officially terminated in 1992. Since that time, the Lynchburg Technology Center has stored this fuel under contract to DOE (DOE 1993c).

The DOE-owned spent fuel rods that are stored in the spent fuel storage pool are intact and in good condition. Water quality is also good and is maintained by passing through particulate filters and resin beds. No chemistry controls have been needed. In addition, sludge is not present in the pool and biological contamination has not been observed (DOE 1993c).

There are no routine inspections of the condition of spent fuel rods that have been sectioned and placed in dry storage. However, some of the fuel stored in this facility was recently repackaged and moved; this fuel and its containers are known to be in good condition. Other evidence that the integrity of spent fuel storage containers has been maintained in good condition is routine monitoring of groundwater, direct radiation, and smearable contamination, all of which indicate that leakage of radionuclides is not occurring (DOE 1993c).

Groundwater and other radionuclide monitoring have not indicated any radionuclide releases from the SNF storage facilities at the B&W Lynchburg Technical Center. There is currently no reason to suspect that spent fuel storage containers will degrade in the near term in a manner that would result in a release of fission products. This facility is routinely inspected and relicensed by the NRC every 5 years. Hence, any developing storage problems would most likely be dealt with and corrected under the direction of the NRC (DOE 1993c).

4.2 Decentralization

The Decentralization Alternative is similar to the No Action Alternative except that limited off-site shipments would occur from university and domestic non-DOE research reactors. Impacts of transportation are described in Appendix I to Volume 1. Some DOE facilities would be upgraded/replaced and additional on-site storage capacity would be required at several DOE facilities. Essentially, there are no differences from the No Action Alternative, except impacts from transportation, facility upgrade, and new construction.

At Brookhaven National Laboratory High Flux Beam Reactor, some land disturbance might be anticipated from the installation of additional SNF storage capacity, whether wet or dry. However, any such disturbance is expected to occur in previously disturbed on-site areas.

4.3 1992/1993 Planning Basis

The 1992/1993 Planning Basis Alternative would permit the shipment of the SNF currently in storage or being generated at the originating sites. With the implementation of the 1993/93 Planning Basis Alternative, as in past practice, SNF would continue to be shipped from the originating sites to a DOE receiving site. The 1992/1993 Planning Basis Alternative would be expected to have essentially no incremental impact on the originating sites. Impacts of transportation are described in detail in Appendix I to Volume 1. The alternative of transporting SNF by barge from Brookhaven National Laboratory is also described in Appendix I to Volume 1.

4.4 Regionalization

The Regionalization Alternative would be the same as the 1992/1993 Planning Basis Alternative, except for the difference in destinations. Implementation of the Regionalization Alternative would permit the shipment of SNF from originating sites to regional DOE interim storage facilities. The Regionalization Alternative would be expected to have essentially no incremental impact on the originating sites. Impacts of transportation are described in detail in Appendix I to Volume 1.

4.5 Centralization

The Centralization Alternative would be the same as the 1992/1993 Planning Basis Alternative, except for the difference in destinations. Implementation of the Centralization Alternative would permit the shipment of SNF from originating sites to a central DOE interim storage facility. The Centralization Alternative would be expected to have essentially no incremental impact on the originating sites. Impacts of transportation are described in detail in Appendix I to Volume 1.

5.0 CUMULATIVE IMPACTS

This section describes the cumulative environmental impacts of the alternatives for generating and storing SNF at the originating sites addressed in this Appendix. The emphasis is on DOE SNF Alternative 1, No Action, under which all SNF would remain at the originating facility. For the individual originating facilities, the cumulative impact is defined as the sum of the incremental impacts of SNF management under the No Action Alternative and the impacts of the other operations at the facility's reactor(s) or other activities involving radioactive materials. For the other alternatives, the SNF cumulative impact at the originating facilities essentially would end with the removal of the SNF from the site. The cumulative impacts of intersite SNF transportation alternatives on transportation routes and affected communities are analyzed programmatically in Volume 1, Appendix I. The cumulative impacts at the DOE facilities receiving SNF are addressed in Appendixes A, B, C and F.

5.1 DOE Test and Experimental Reactors

Under the No Action Alternative, the cumulative environmental impacts at DOE test and experimental reactors are derived from past environmental impacts as obtained from annual operating reports, and estimated future impacts based on extrapolation to the year 2035 of past impacts.

5.1.1 Brookhaven National Laboratory

It is expected that the High Flux Beam Reactor and Brookhaven Medical Research Reactor would continue to operate, for all SNF management alternatives except No Action. If additional storage were to be required on-site to accommodate High Flux Beam Reactor SNF through 2035, current impacts would be somewhat increased by the impacts of building and operating an additional facility. Although the nature of that facility has not been determined, the resulting impacts are expected to be negligibly small. Should the facility propose substantial changes, appropriate NEPA documentation would be prepared in accordance with existing environmental regulations.

5.1.2 Los Alamos National Laboratory

Omega West Reactor at the Los Alamos National Laboratory is permanently shut down and is being decommissioned. The spent fuel is in temporary dry storage at the Chemistry and Metallurgy Research complex, and resulting impacts are negligible. The spent fuel is awaiting relocation. Cumulative impacts would not change under any alternative.

5.1.3 Sandia National Laboratories

The cumulative environmental impacts would not change from those currently experienced at Sandia National Laboratories from the operation of the reactors and storage of small quantities of SNF.

5.1.4 Argonne National Laboratory - East

The cumulative environmental impacts would not change from those currently experienced from the storage of small quantities of SNF.

5.2 Domestic Research Reactors

Under the No Action Alternative, the cumulative environmental impacts at domestic research reactors are a composite of past environmental impacts as obtained from annual operating reports, and estimated future impacts based on extrapolation to the year 2035 of past impacts. The following facility-specific cumulative environmental impacts have been selected as representative of all domestic research reactor facilities that could be affected by Alternative 1.

5.2.1 National Institute of Standards and Technology

Implementation of the No Action Alternative would result in the shutdown of the National Bureau of Standards Reactor in October 1996 due to the inability to store additional SNF. The environmental radiological impact of such action would be a reduction of radioactive releases and doses below those of full power operation. On-site SNF storage would meet existing facility design criteria. There would be no other change in the cumulative environmental impact except for the adverse socioeconomic impacts as a result of the loss of services and knowledge from reactor operations.

A scenario of continued operation, assuming timely reissuance of the operating license, including compliance with the National Environmental Policy Act, would bound the cumulative environmental impacts under any of the DOE-postulated SNF alternatives.

5.2.2 Massachusetts Institute of Technology

As with the National Institute of Standards and Technology, the Massachusetts Institute of Technology research reactor would be expected to shut down in response to the No Action Alternative because of limited SNF storage capacity. Thus, a scenario of continued operation, assuming timely reissuance of the operating license, would bound the cumulative environmental impacts under any of the DOE-postulated SNF alternatives.

5.2.3 Conclusion

For all domestic research reactors, the SNF management alternatives, including the No Action Alternative, would not increase the cumulative impacts of the originating sites above current values. Some of the facilities could not be able to continue normal operation under the No Action Alternative and could be forced to shut down due to the lack of SNF storage capacity. Reactors licensed by the U.S. Nuclear Regulatory Commission are not under DOE control, and additional storage space could be constructed under the No Action Alternative. However, except for the negative socioeconomic impacts attributable to the loss of services and knowledge resulting from such shutdowns, other site-specific cumulative impacts would not be increased.

5.3 Nuclear Power Plant Spent Nuclear Fuel

The implementation of any one of DOE's five SNF management alternatives would have no additional environmental consequences beyond those already evaluated for the Fort St. Vrain and B&W Lynchburg facilities.

The situation is similar for the West Valley Demonstration Project, except that the DOE has entered into an agreement with the New York State Energy Research and Development Authority which calls for the removal of SNF from the West Valley Demonstration Project. Implementation of the No Action and Decentralization Alternatives would result in SNF remaining at the West Valley Demonstration Project. If the fuel remains at the West Valley Demonstration Project, the SNF may be managed in a new dry storage facility. Once the SNF is in dry storage, there will be no releases of radioactive effluents and an indistinguishable direct radiation exposure to the environs in excess of that which would occur were the SNF to be moved as scheduled, and in the payment of storage costs by DOE to the State of New York.

6.0 ADVERSE ENVIRONMENTAL EFFECTS

THAT CANNOT BE AVOIDED

Unavoidable adverse impacts addressed here are limited to those occurring as a result of DOE Alternative 1 (No Action) at the originating facilities discussed in this Appendix. All other alternatives consider normal shipment of SNF from the originating site, with only transportation routes and the receiving site possibly being subjected to unavoidable adverse impacts by transferred SNF. Any adverse impacts at the originating sites are thus precluded for all SNF transportation alternatives. Possible unavoidable adverse impacts on transportation routes are analyzed in Volume 1, Appendix I. Possible unavoidable adverse impacts at the DOE facilities that receive SNF are addressed in Appendixes A, B, C and F.

6.1 DOE Test and Experimental Reactors

The adverse effects that may be unavoidable caused by implementation of the No Action Alternative would be associated with the possible premature, long-term shutdown of the High Flux Beam Reactor at Brookhaven National Laboratory. The consequences of this shutdown would be cessation of site specific activities involving unique experiments. These experiments are needed for understanding materials structures, biological processes, and the behavior of super conducting materials. Shutdown would also cause the loss of jobs associated with these experiments and supporting site activities.

6.2 Domestic Research Reactors

The adverse effects that may be unavoidable at domestic research reactors caused by implementation of the No Action Alternative would be associated with the possible premature, long-term shutdown of several reactors. The consequences of these shutdowns, discussed in Section 4.1.2, would be cessation of site-specific research and education activities and could result in the loss of jobs associated with these activities at these sites.

6.3 Nuclear Power Plant Spent Nuclear Fuel

Implementation of the No Action Alternative could result in adverse consequences that may be unavoidable at West Valley Demonstration Project. Should this alternative be selected, the adverse impact that may be unavoidable would be continued on-site and off-site radiation exposures beyond the scheduled fuel removal date as a result of radioactive effluents and/or direct radiation.

Since the Public Services Company of Colorado has already responded to the No Action Alternative by licensing and constructing an independent spent nuclear fuel storage installation at its Fort St. Vrain site, no additional consequences or additional adverse consequences would be incurred there.

7.0 IRREVERSIBLE AND IRRETRIEVABLE

COMMITMENTS OF RESOURCES

The assessment of the activities undertaken at the SNF originating sites as a consequence of the implementation of all alternatives indicates that only minor irreversible and irretrievable commitments of resources would be required.

7.1 DOE Test and Experimental Reactors

If the Decentralization Alternative were to be implemented, the Brookhaven National Laboratory would expect to be required to identify some way to store the SNF generated by the High Flux Beam Reactor through the year 2035. Several scenarios are possible, but none has been decided upon at this time. One possible SNF management scenario is to install additional storage accommodations. Limited quantities of construction materials and fuel for construction equipment would be required if this scenario were selected.

Implementation of the No Action Alternative would not result in any irreversible and irretrievable commitments at the Los Alamos National Laboratory, Sandia National Laboratories or Argonne National Laboratory - East.

Implementation of any of the other proposed alternatives for SNF would not result in any additional irreversible and irretrievable commitments of resources at the DOE test and experimental reactors.

7.2 Domestic Research Reactors

There are no substantial new irreversible and irretrievable commitments of resources at the domestic research reactors with the implementation of any of the proposed SNF alternatives for generating and storing SNF. If, under the No Action Alternative, any NRC-licensed facility should elect to modify its SNF storage capabilities, a site-specific license amendment would be required. If the storage facilities were expanded, there would be a commitment of construction materials and fuel to operate construction equipment. The other DOE SNF alternatives would involve no commitment of resources at domestic research reactor facilities.

7.3 Nuclear Power Plant Spent Nuclear Fuel

Implementation of the Decentralization Alternative could result in irreversible and irretrievable commitments of resources at the West Valley Demonstration Project site. Should this alternative be selected, this commitment of resources would result from the construction materials and fuels used to provide alternative on-site SNF storage capability. The magnitude of these commitments cannot be quantified, however, until it is determined whether existing SNF storage capacity would be modified or a new SNF storage facility would be constructed and its type.

Implementation of any of the other proposed alternatives for SNF would not result in any additional irreversible and irretrievable commitments of resources at the commercial SNF storage facilities.

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APPENDIX F Nevada Test Site and Oak Ridge Reservation Spent Nuclear Fuel Management Programs

Department of Energy Programmatic
Spent Nuclear Fuel Management
and
Idaho National Engineering Laboratory
Environmental Restoration and
Waste Management Programs
Final Environmental Impact Statement
Volume 1
Appendix F
Nevada Test Site and Oak Ridge Reservation
Spent Nuclear Fuel Management Programs
April 1995
U.S. Department of Energy
Office of Environmental Management
Idaho Operations Office

1. APPENDIX F INTRODUCTION

This appendix addresses the interim storage of spent nuclear fuel (SNF) at two U.S. Department of Energy sites, the Nevada Test Site (NTS) and the Oak Ridge Reservation (ORR). These sites are being considered to provide a reasonable range of alternative settings at which future SNF management activities could be conducted. These locations are not currently involved in management of large quantities of SNF; NTS has none, and ORR has only small quantities. But NTS and ORR do offer experience and infrastructure for the handling, processing and storage of radioactive materials, and they do exemplify a broad spectrum of environmental parameters. This broad spectrum of environmental parameters will provide a perspective on whether and how such location attributes may relate to potential environmental impacts. Consideration of these two sites will permit a programmatic decision to be based upon an assessment of the feasible options without bias to the current storage sites.

This appendix is divided into three parts. Part One is the Appendix F introduction. Part Two contains chapters one through five for the NTS, as well as the NTS references in chapter six and acronyms and abbreviations in Chapter 7. Part Three contains chapters one through five for the ORR, as well as the ORR references in chapter six and abbreviations and acronyms in Chapter 7. A Table of Contents, List of Figures, and List of Tables are included in Parts Two and Three. This approach permitted the inclusion of both sites in one appendix while maintaining chapter numbering consistent with Volume 1 and Appendices A, B, and C.

Currently, no SNF is stored at the NTS and only small quantities of SNF generated by research reactors at ORR are stored there. In order to receive, handle, and store spent nuclear fuel from other DOE sites on an interim basis, new facilities would need to be constructed at the NTS and ORR. Since the basic facilities to receive and handle the spent fuel, as well as any safety-related and emergency containment, cleanup, and recanning facilities, are approximately equivalent for all alternatives being considered, only the size of the storage facility will vary for each alternative, with the Centralization Alternative requiring the largest storage facility. As discussed in Chapter 3, only the Centralization Alternative for spent fuel storage at either the NTS or ORR is analyzed quantitatively in this volume; the Regionalization Alternative is evaluated qualitatively. The results of this appendix are then summarized in Volume 1.

NEVADE TEST SITE

FIGURES

TABLES

#1. INTRODUCTION

This part assesses the impacts of construction and operation of proposed spent nuclear fuel (SNF) facilities at the Nevada Test Site (NTS). The NTS is being evaluated for these facilities because of the area available, the isolation of population centers, the apparently suitable site environmental parameters, previous U.S. Department of Energy activities involving radioactive materials at the site, and the planned long-term government control of the site.

This part is organized as follows. Chapter 1 is the introduction, Chapter 2 sets the stage for the area under analysis by providing an overview of the NTS and discussions of the Regulatory Framework and SNF Management Program, and Chapter 3 explains the SNF alternatives being considered at the site.

Chapter 4 describes the human and natural environment that could be affected as a result of the introduction of an SNF facility at the NTS. Environmental parameters such as water resources, socioeconomics, biological resources and air quality are examples of those characterized.

Chapter 5 enumerates the environmental consequences that might be anticipated, the cumulative impacts, the unavoidable adverse impacts, the relationship between short-term use and long-term productivity, the irreversible and irretrievable commitment of resources, and possible mitigation measures that might be anticipated if an SNF facility were built at the NTS. Chapter 6 contains the references used to develop this part of the Environmental Impact Statement. Chapter 7 contains the abbreviations and acronyms used in this Part.

2. NEVADA TEST SITE BACKGROUND

2.1 Overview

2.1.1 Site Description

The Nevada Test Site (NTS), located in the southeastern portion of Nevada, is operated by the U.S. Department of Energy (DOE) as the on-continent test site for nuclear weapons testing. The site encompasses approximately 1,350 square miles (3,500 square kilometers). The NTS is surrounded on the north, east, and west by the Nellis Air Force Base (NAFB) Bombing and Gunnery Range. Together with the Tonopah Test Range, these three properties provide a 15- to 65-mile (24- to 104-kilometer) buffer zone between the test areas and public lands. The Bureau of Land Management owns land on the southern and southwestern borders of the NTS. Las Vegas is approximately 65 miles (104 kilometers) from the southeast corner of the site (Figure 2.1-1) (DOE/NV 1991a; USAF et al. 1991).

The NTS is a large, open area, tightly controlled, with the infrastructure to conduct tests with hazardous and radioactive materials. Security at the NTS consists of security guards, often using four-wheel drives, patrolling the site. The perimeter of the site is not fenced. Armed guards and electronic security measures are in place for secure areas. Approximately 25 percent of the site is unused or is used as a buffer zone for ongoing programs or projects (DOE/NV 1991a; USAF et al. 1991).

The NTS is broken into numbered test areas to simplify the distribution, use, and control of resources (Figure 2.1-2). Area 22, the site's main entrance, is located on the southeast corner of the site and contains the Desert Rock airstrip. Area 23, adjacent to Area 22, contains the Mercury base camp, which houses administrative operation and general support activities. Offices for the DOE, the U.S. Department of Defense (DoD), Defense Nuclear Agency, Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory (LANL), Sandia National Laboratories (SNL), and all supporting contractors of these organizations are located in this area. Other facilities in this area include the cafeteria, recreation, transportation, and housing. Area 5 (Frenchman Flat) was used in the past for nuclear testing. Area 6, north of Figure 2.1-1. Nevada Test Site regional map. Figure 2.1-2. Nevada Test Site map. Area 5, contains the Control Point One facility which overlooks Yucca Flat, where a large portion of the testing occurs. This facility provides control over and execution of nuclear detonations at the NTS. Also in Area 6 there is a new work camp which is used for construction and craft support. Other areas located on the NTS are the valley of the Yucca Flat (Areas 3, 7, and 9), the Rainier Mesa (Area 12), which is the center of DoD/Defense Nuclear Agency activities, and the Pahute Mesa (Areas 19 and 20) (DOE/NV 1991a; ERDA 1977; USAF et al. 1991). Area 5 will be housing the proposed spent nuclear fuel (SNF) facilities. Figure 2.1-2 shows the approximate location of the proposed SNF facility. The actual location will be determined for site-specific environmental documentation.

2.1.2 Site History

Prior to 1951, the land which is now occupied by the NTS was used for mining and grazing. Primarily, mining was for low grades of copper, lead, silver, gold, mercury, and tungsten. Although there were short periods of mining success at the site, the area was abandoned over time. Grazing ended in 1955 when the Federal government acquired the water and grazing rights of two ranches which were operating on what is now the NTS (ERDA 1977).

Since January 1951, the land now occupied by the NTS has been the primary location for nuclear weapons testing in the United States. Land was withdrawn from the NAFB Bombing and Gunnery Range in 1952 to form the NTS. Subsequent withdrawals occurred in 1958, 1961, and 1962. A Memorandum of Understanding between NAFB and the NTS in 1967 allowed the use of Pahute Mesa by the NTS (DOE/NV 1991a; USAF et al. 1991).

Most of the tests performed at the NTS in the 1950s were atmospheric tests. After 1951, nuclear tests were carried out intermittently until a voluntary moratorium ended testing in October 1958. The first full-scale nuclear detonation occurred in 1957 in a sealed tunnel. Testing resumed in September 1961 following the ending of the moratorium. Atmospheric testing ended in the summer of 1963 following the signing of the Limited Test Ban Treaty. Since 1962, all testing has occurred underground. Two methods have been used for underground testing since 1963: vertical shafts (from the valley of Yucca Flat to the top of Pahute Mesa) and horizontal tunnels (Rainer Mesa) (DOE/NV 1991a; ERDA 1977; USAF et al. 1991).

In addition to underground testing, between 1962 and 1968, earth-cratering tests were conducted as part of the Plowshare Program. This program explored peaceful means of using nuclear explosives. Other tests which have occurred on the NTS have included the Bare Reactor Experiment (1960s) and the open air nuclear reactor, nuclear engine, and nuclear furnace tests (1959-1973). Much of the nuclear testing has been conducted on the NTS by the LANL, LLNL, SNL and, through the Defense Nuclear Agency, the DoD. Non-nuclear testing has included hazardous material spills. Other activities which occur on the NTS are the storage and disposal of low-level radioactive wastes and mixed wastes (DOE/NV 1991a; ERDA 1977; USAF et al. 1991).

As part of DOE's program to establish a national repository for high-level radioactive waste, Lawrence Livermore National Laboratory conducted an evaluation of the effects of radiation and heat from radioactive decay on granite rock formations. The project, known as Spent Fuel Test - Climax, stored 11 spent fuel elements from the Florida Power & Light Company and 6 electric heat simulators in specially designed and constructed holes in the Climax tunnel, located in the northeastern corner of the NTS in Area 15. The SNF, in hermetically sealed canisters, was emplaced in the granite formation, stored for approximately 3 years, retrieved, and then transferred, in 1986, to INEL for further testing (DOE/NV 1983, 1986a).

2.1.3 Nevada Operations Office Mission

The missions of the NTS and/or the DOE Nevada Operations Office include:

- Maintaining the capability to conduct underground nuclear weapons tests.
- Conducting all programs related to nuclear emergencies and threats.
- Supporting arms control, treaty verification, and non/counter proliferation of nuclear weapons technology.
- Supporting research activities as part of being designated a National Environmental Research Park.
- Conducting tests for the Liquefied Gaseous Fuels Spill Testing Program.
- Supporting studies in alternate energy sources and environmental management, research and development, and testing.
- Ensuring that all operations are conducted in compliance with all environmental, safety, and health laws, regulations, standards, agreements, and DOE Orders (DOE/NV 1993b, 1992a, 1991a; ERDA 1977).

2.1.4 Nevada Test Site Management

The DOE Nevada Operations Office is currently administering NTS operations. The NTS has multiple contractor support. The major support contractors are Reynolds Electrical &

Engineering Co., Inc., the prime contractor; EG&G Energy Measurements, Inc., the electronic and instrumentation support contractor; Raytheon Services Nevada, the architect-engineering support contractor; and Wackenhut Services, Inc., the site security contractor.

2.1.5 Yucca Mountain Project

The DOE Office of Civilian Waste Management is conducting a program for siting the nation's first geologic repository for spent nuclear fuel and other high-level radioactive wastes.
The Yucca Mountain Site has been designated by the U.S. Congress as a candidate site. Although Yucca Mountain is located outside the western boundary of the NTS, a contiguous portion of the NTS has been assigned as part of the potential repository site. Access to the site is accomplished through the NTS and Yucca Mountain Project field offices and support facilities are located in Area 25 (DOE/NV 1993b). Currently, Yucca Mountain is being characterized to study its suitability as a geological repository. The characterization study includes exploratory borings and analyses of meteorological, geological, hydrological, geochemical, erosion, tectonics, and socioeconomics conditions. Upon completion of the characterization study, the Secretary may recommend Yucca Mountain to the U.S. President as viable site for a repository (DOE 1988b).

2.2 Regulatory Framework

The National Environmental Policy Act (NEPA) of 1969 (42 U.S.C. 4321-4347, as amended) provides Federal agency decision makers with a process to systematically consider the potential environmental consequences of agency decisions. The DOE has prepared this environmental impact statement (EIS) in conformance with the requirements of this Act to evaluate the potential impacts of programmatic decisions on the management of SNF. This EIS will provide the necessary background, data, and analyses to help decision makers understand the potential environmental consequences of each alternative.

On October 22, 1990, the DOE published a Notice of Intent in the Federal Register (FR 1990a) announcing its intent to prepare a programmatic EIS addressing environmental restoration and waste management (including SNF management) activities across the entire DOE Complex. On October 5, 1992, the DOE published a Notice of Intent in the Federal Register (FR 1992) announcing its intent to prepare an EIS addressing environmental restoration and waste management and SNF activities at the Idaho National Engineering Laboratory. For further programmatic discussion of this topic, see Volume 1.

Significant Federal and state environmental and nuclear materials management laws are applicable to the NTS. The Federal laws are listed in Volume 1, Section 7.3. The State of Nevada laws are listed alphabetically below:

- Air Pollution Control Law (Title 40 Chapter 445)
- Air Quality Regulations (Title 40 Chapter 445)
- Disposal of Hazardous Waste (Title 40 Chapter 444)
- Disposal of Radioactive Material (Title 40 Chapter 459)
- Facilities for the Management of Hazardous Waste (Title 40 Chapter 444)
- Regulation of Highly Hazardous Substances (Title 40 Chapter 459)
- Solid Waste Disposal Act (Title 40 Chapter 444)
- Storage Tanks (Title 40 Chapter 459)
- Underground Injection Control (Title 40 Chapter 445)
- Water Pollution Control Law (Title 40 Chapter 445)
- Water Pollution Regulations (Title 40 Chapter 445)

2.3 Spent Nuclear Fuel Management Program

Currently, spent nuclear fuel is not generated, received, reprocessed, or stored at the NTS; therefore, a SNF management program does not currently exist for activities at the NTS (DOE 1993). There are no current or foreseeable environmental, safety, or health vulnerabilities at the NTS associated with SNF (DOE 1993). Selection of the No-Action Alternative would not adversely affect the operations or any planned facility modifications at the NTS.

3. SPENT NUCLEAR FUEL ALTERNATIVES

3.1 Description of Management Alternatives

This chapter describes the spent nuclear fuel (SNF) management alternatives evaluated by the U.S. Department of Energy (DOE) for Appendix F that are applicable to the Nevada Test Site (NTS). DOE did not consider the Nevada Test Site to be a preferred site for the management of spent nuclear fuel in the Draft EIS because of the State's current role as the host site for the Yucca Mountain Site Characterization Project. DOE's identification of the preferred alternatives also indicates that DOE does not consider the Nevada Test Site as a preferred site for spent nuclear fuel management in the Final EIS. For the purposes of conducting a thorough NEPA analysis, the NTS provides a contrast to other potential sites because it represents a site that has no existing SNF management infrastructure. The NTS does not currently generate or store any SNF. Hence, of the five alternatives discussed in this Programmatic Environmental Impact Statement (EIS), only two, Regionalization and Centralization, are applicable to the NTS. The other three alternatives -- No Action, Decentralization, and the 1992/1993 Planning Basis -- are not applicable to the NTS since they affect or involve only sites which currently generate or store SNF.

3.1.1 Alternative 1 - No Action

The No Action Alternative is restricted to the minimum actions necessary for the continued safe and secure management of SNF. As defined, this alternative stipulates no SNF shipments to or from DOE facilities. The NTS does not currently generate or store any SNF and would not receive any SNF under this alternative. Therefore, this alternative is not applicable to the NTS and is not analyzed or discussed further in this or subsequent chapters for the NTS.

3.1.2 Alternative 2 - Decentralization

Decentralization involves storage of SNF at or close to generation sites, with limited shipments to the Idaho National Engineering Laboratory (INEL) and Savannah River Site (SRS) as necessary to permit continued operation. Since the NTS does not generate or store any SNF and would not receive any SNF under this alternative, it is not applicable to the NTS and is not analyzed or discussed further in this or subsequent chapters for the NTS.

3.1.3 Alternative 3 - 1992/1993 Planning Basis

The 1992/1993 Planning Basis Alternative is DOE's documented 1992/1993 plan for the management of DOE and Naval SNF. Since the NTS does not generate or store any SNF and would not receive any SNF under this alternative, it is not applicable to the NTS and is not analyzed or discussed further in this or subsequent chapters for the NTS.

3.1.4 Alternative 4 - Regionalization

3.1.4.1 Overview. The Regionalization Alternative consists of two subalternatives.

Subalternative A would distribute existing and new SNF between the Hanford Site, INEL, and SRS by SNF type. Under Subalternative B, SNF would be distributed to either an eastern or western regional site based on geographical location. SNF east of the Mississippi River would be shipped to the eastern region site (i.e., SRS or Oak Ridge Reservation (ORR)). SNF west of the Mississippi River would be shipped to the western regional site (i.e., Hanford, INEL, or NTS). Additionally, all Naval SNF would be shipped to only one of the sites, but not both. The ORR would be the alternative to the SRS as the eastern regional site, and the NTS would be the alternative to both the Hanford Site and INEL as the western regional site.

3.1.4.2 Regionalization Subalternative B. The following fuels would be transported to

the NTS for storage under the Regionalization Subalternative B:

- Naval-type SNF (if selected)
    - All, including from the INEL, shipyards, and prototypes
- Hanford Production SNF
    - From western sites including the Hanford Site
- Graphite SNF
    - From western sites including the INEL and Public Service of Colorado
- DOE-Owned Commercial SNF
    - From western sites including the Hanford and INEL
- Experimental - Stainless steel SNF

  - From western sites including the Hanford, INEL, Foreign Research Reactors, and non-DOE domestic research reactors
- Experimental - Zirconium SNF
  - From western sites including the INEL
- Experimental - Other
  - From western sites.
- SRS Production and Aluminum SNF
  - From western sites including INEL, Los Alamos National Laboratory (LANL), Foreign Research Reactors, and non-DOE domestic research reactors

All SNF presently in storage at DOE facilities would arrive at the NTS stabilized and canned to the extent necessary for safe transportation. However, this SNF might need to be uncanned, stabilized, prepared, and recanned at the NTS to ensure safe interim storage. New non-DOE domestic, Foreign Research Reactors, and Naval SNF would be shipped in the state necessary for safe transportation but not necessarily canned. This fuel would be stabilized, prepared, and canned at the NTS to ensure safe interim storage. All fuel would be cooled for a minimum of 120 days prior to shipping and 5 years before being placed in dry storage. Additionally, if the NTS is selected for the Expended Core Facility, Naval SNF would be examined at the NTS before being turned over for interim storage management.

The NTS currently has no facilities that are suitable for receiving, canning, storing, or supporting the research activities necessary for the safe management of SNF. As a result, a new SNF management complex would be built at the NTS under the Regionalization Subalternative B. The SNF management complex would include the following:

- SNF receiving and canning facility
- Technology development facility
- Interim dry storage area
- Expended Core Facility similar to the one at the INEL (if selected for Naval Fuel Receipt).

The SNF receiving and canning facility would receive SNF cask shipments from offsite and prepare the SNF for dry storage. A pool storage area would be included in this facility for cooling SNF before it is placed into dry storage, as necessary. The technology development facility would investigate the applicability of dry storage technologies and pilot scale technology development for disposal of the various types of SNF. The interim dry storage area would consist of passive storage modules designed to safely store the SNF for 40 years. If NTS is selected for Naval fuel receipt, Naval SNF would be examined at the Expended Core Facility prior to being turned over for interim storage management.

The SNF management complex which would be built at the NTS under the Regionalization Alternative would have the same components as that built under the Centralization Alternative. However, the dry storage component would be somewhat smaller due to the smaller SNF inventory that would be transported to the NTS under the Regionalization Alternative. The other components of the SNF management complex would be the same general size as those built under the Centralization Alternative. This is because the inventories of new uncanned fuel which would be sent to the NTS under the Regionalization and Centralization Alternatives would be very similar. Additionally, since the major portion of the potential radiological and chemical releases and waste generation rates are associated with these components, the Regionalization Alternative will not be analyzed separately. This alternative will be compared to the Centralization Alternative in a semiquantitative manner.

If the NTS is not chosen as the western regional site, the Regionalization Alternative would not be applicable to the NTS.

3.1.5 Alternative 5 - Centralization

3.1.5.1 Overview. Under Centralization, all existing and new SNF would be shipped to

one site. There are five Centralization options considered in this PEIS; Option A - Hanford Site, Option B - INEL, Option C - SRS, Option D - ORR, Option E - NTS. If the NTS was chosen as the centralization site, all SNF currently stored at the HS, INEL, SRS, ORR, and other sites currently storing DOE fuel would be transferred to the NTS.

3.1.5.2 Centralization Alternative Option E. The following fuels would be transported to

the NTS for storage under the Centralization Alternative Option E:

- Naval-type SNF
  - From the INEL and shipyards
- Hanford Production SNF
  - From the Hanford Site
- Graphite SNF
  - From the INEL and Public Service of Colorado
- DOE-Owned Commercial SNF

    - From Hanford, INEL, West Valley Demonstration Project, and B&W Lynchburg
- Experimental - Stainless Steel SNF
    - From Hanford, INEL, SRS, FRR, and non-DOE domestic research reactors
- Experimental - Zirconium SNF
    - From the INEL and SRS
- Experimental - Other
    - From the Oak Ridge National Laboratory (ORNL)
- SRS Production and Aluminum SNF
    - From the INEL, SRS, ORNL, LANL, Brookhaven National Laboratory, Foreign Research Reactors, and non-DOE domestic research reactors.

All SNF presently in storage at DOE facilities would arrive at the NTS stabilized and canned to the extent necessary for safe transportation. However, this SNF may need to be uncanned, stabilized, prepared, and recanned at the NTS to ensure safe interim storage. New non-DOE domestic research reactor, Foreign Research Reactor, and Naval SNF would be shipped in a state necessary for safe transportation but not necessarily canned. This fuel would be stabilized, prepared, and canned at the NTS to ensure safe interim storage. All fuel would be cooled for a minimum of 120 days prior to shipping and 5 years before being placed in dry storage. Additionally, Naval SNF would be examined at the NTS before being turned over for interim storage management.

The NTS currently has no facilities that are suitable for receiving, canning, storing, or supporting the research activities necessary for the safe management of SNF. As a result, a new SNF management complex would be built at the NTS under the Centralization Alternative Option E. The SNF management complex would include the following:

- SNF receiving and canning facility
- Technology development facility
- Interim dry storage area
- Expended Core Facility similar to the one at the INEL.

The SNF receiving and canning facility would receive SNF cask shipments from offsite and prepare the SNF for dry storage. A pool storage area would be included in this facility for cooling SNF before it is placed into dry storage, as necessary. The technology development facility would investigate the applicability of dry storage technologies and pilot scale technology development for disposal of the various types of SNF. The interim dry storage area would consist of passive storage modules designed to safely store the SNF for 40 years. Naval SNF would be examined at a new Expended Core Facility constructed at the NTS prior to being turned over for interim storage management.

The SNF management complex which would be built at the NTS under the Centralization Alternative would have the same components as those built under the Regionalization Alternative. However, the dry storage component would be somewhat larger under the Centralization Alternative due to the somewhat greater SNF inventory that would be transported to the NTS under this alternative. The other components of the SNF management complex would be the same general size as those built under the Regionalization Alternative. This is because the inventories of new uncanned fuel which would be sent to the NTS under the Regionalization and Centralization Alternatives would be very similar. Additionally, the major portion of the potential radiological and chemical releases and waste generation rates are associated with these components, and would not be significantly different for the two alternatives. Therefore, this alternative will be used as the basis for a semiquantitative comparison with the Regionalization Alternative.

If the NTS is not chosen as the centralization site, the Centralization Alternative would not be applicable to the NTS.

3.2 Comparison of Alternatives

Table 3.2-1 shows a comparison of the alternatives. The Regionalization Alternative column does not include the requirements of the Naval Expended Core Facility, although this facility may be constructed at the site under this alternative. The Centralization Alternative column does include the requirements of the Naval Expended Core Facility, which are presented in Volume 1, Appendix D, since this facility will be built at the site under this alternative.

Table 3.2-1. Comparison of alternatives for the NTS.

Parameter	Regionalization Subalternative B	Centralization Option E[a] at NTS
Land for new facilities (acres)	90	120
Site area (acres)	864,000	864,000
Percent of site area	0.01	0.01
SNF-related employment[b]	556	1,118
Baseline site employment	8,563	8,563
Percent of baseline site employment	6.5	13.1
Estimated cancer fatalities in 80-km population per year, SNF management	4.1 x 10^{-5}	

operationsc		4.1 x 10-5
Estimated cancer fatalities in 80-km population per year, other site operations	2.6 x 10-6	2.6 x 10-6
Estimated probability of cancer fatalities in a maximally exposed individual per year, SNF management operationsc	5.9 x 10-8	5.9 x 10-8
Estimated probability of cancer fatalities in a maximally exposed individual per year, other site operations	5.5 x 10-9	5.5 x 10-9
Estimated probability of cancer fatality in average worker per year, SNF management operationsc	1.6 x 10-5	1.6 x 10-5
Estimated maximum probability of cancer fatality in average worker per year, other site operations	2.0 x 10-6	2.0 x 10-6
Water use (million gallons) per year, SNF management	3.6	6.1
Baseline water use (million gallons) per year, site operations	1,120	1,120
Percent of baseline site water use	0.32	0.54
Electricity use (megawatt-hours) per year, SNF management	23,000	33,000
Baseline electricity use (megawatt-hours) per year, site operations	183,100	183,100
Percent of baseline site electricity use	12.56	18.02
Sewage discharge (million gallons) per year, SNF management	3.6	6.1
Baseline sewage discharge (million gallons) per year, site operations	0	0

Parameter	Regionalization Subalternative B	Centralization Option Ea at NTS
Percent of baseline site sewage discharge	NA	NA
High-level waste (cubic meters) per year, SNF management	0	0
Transuranic waste (cubic meters), SNF management	16	16
Mixed waste (cubic meters), SNF management	0	0
Low-level waste (cubic meters), SNF management	203	628
Estimated maximum cancer fatalities in 80-km population from maximum risk accident	6.6 x 10-4	
Frequency of occurrence (number per year)d	1.6 x 10-1	
Estimated maximum risk of cancer fatalities in 80-km population from maximum risk accident (cancer fatalities per year)d	1.1 x 10-4	
Estimated maximum worker cancer fatalities from maximum risk accidentd	1.9 x 10-3	
Frequency of occurrence (number per year)d	1.0 x 10-4	
Estimated maximum risk of worker cancer fatalities from maximum risk accident (cancer fatalities per year)d	1.9 x 10-7	

a. Centralization Option includes the Naval Expended Core Facility results from Volume 1, Appendix D.
b. Annual Average SNF direct construction and operation jobs over the 10-year period 1995 to 2005.
c. Excludes baseline site operations.
d. Centralization Option is the same as the Regionalization Option for the SNF Management Facility and does not include the Naval Expended Core Facility accident analyses results from Volume 1, Appendix D.

4. AFFECTED ENVIRONMENT

4.1 Overview

This chapter describes the existing environmental conditions in areas potentially affected by a programmatic decision to site spent nuclear fuel (SNF) facilities at the Nevada Test Site (NTS) under the Centralization and Regionalization Alternatives. Topics were selected for analysis based upon their potential to be affected by the alternatives. Each topic is addressed in the detail necessary to serve as a baseline for assessment of potential environmental consequences in Chapter 5.

4.2 Land Use

The NTS occupies an area of approximately 1,350 square miles (3,500 square kilometers) in southern Nevada, in a sparsely populated desert area approximately 65 miles (104 kilometers) northwest of Las Vegas. The NTS is almost entirely surrounded by other federally owned lands which buffer it from lands open to the public. The NTS is bordered by the Nellis Air Force Base (NAFB) Bombing and Gunnery Range on the north, east, and west, and by Bureau of Land Management (BLM) lands on the south and southwest (DOE/NV 1993a,b).

Existing land use on the NTS falls into four general categories: Testing Areas; Buffer/Reserved Areas; Industrial/Research Areas; and Waste Management Areas. According to the latest NTS land use map (Figure 4.2-1), approximately 50 percent of the land on the NTS is buffer/reserved area for ongoing programs or projects (DOE/NV 1993a).

Land bordering the site to the north, east, and west is located on the NAFB Bombing and Gunnery Range and is primarily vacant, unused, or used for a buffer zone. Land bordering the site to the south and southwest is owned by the BLM and is used for recreation, grazing, forest management, or wildlife management (DOE/NV 1993a,b).

The NTS is located in an area of sparsely vegetated desert. Beyond the federally owned lands which surround the NTS, principal land uses in Nye County in the vicinity of the NTS include mining, grazing, agriculture, and recreation (DOE/NV 1993a). Urban and residential land uses occur beyond the immediate vicinity of the NTS, in fertile valley regions such as the Owens and San Joaquin to the west of the site, the Virgin River to the east of the site, the Pahrump to the south of the site, the Moapa River to the southeast of the site, and the Hiko and Alamo to the northeast of the site (DOE/NV 1993b).

Figure 4.2-1. Land use at the Nevada Test Site.

Clark County, to the southeast of the NTS, consists of approximately 7900 square miles (20,220 square kilometers) of which about 95 percent is owned by the federal government (ULI 1992). Primary land uses on these federal lands include grazing, mining, and recreation. The remaining 5 percent of the county supports residential, state and local government, industrial, and retail land uses (Clark County Regional Transportation Commission 1992).

Currently, Nye County does not have a zoning ordinance; therefore, no zoning classification exists for NTS lands. The NTS is required to comply with State of Nevada regulations for air pollution, safety, and transportation, and with Nye County traffic regulations and safety codes (DOE/NV 1993b). Of the total area within Nye County, only a small number of isolated areas are under private ownership and therefore subject to general plan guidelines (NEEDA 1993).

Numerous national, state, and local public recreation areas exist within the NTS region (Figure 2.1-1). Outdoor recreational areas include the Death Valley National Monument, located 12 miles (19 kilometers) to the west/southwest, and the Desert National Wildlife Range, approximately 25 miles (40 kilometers) east. (Portions of the Desert National Wildlife Range are located within NAFB Bombing and Gunnery Range and are as close as 2 miles (3 kilometers) to the NTS). State parks near the site include; the Red Rock Canyon Recreation Lands, approximately 40 miles (64 kilometers) to the southeast; Spring Mountain Ranch State Park, approximately 50 miles (80 kilometers) southeast; and the Floyd R. Lamb State Park, approximately 45 miles (72 kilometers) southeast (BLM 1990).

Other recreational areas include numerous campsites, picnic areas, and sports grounds south of the site in the Toiyabe National Forest, approximately 25 miles (40 kilometers) southeast, and numerous camping and fishing sites north of the site which are used during the spring, summer, and fall months (DOE/NV 1993a,b,c).

The NTS is a controlled area with public access limited to through traffic on U.S. Route 95 and on Lathrop Wells Road (DOE/NV 1993b).

The proposed SNF site is in the northeast portion of Area 5, located in the southeastern part of the NTS. This area is currently designated as the Low-Level Waste Facility Management Area and Buffer/Reserved Area land use categories. This area was also designated as a Non-Nuclear Test Area in the latest NTS Future Land Use Plan (DOE/NV 1993a).

To the east of Area 5, the NTS is bordered by the NAFB Bombing and Gunnery Range, which provides a buffer zone of approximately 50 miles (80 kilometers) between the NTS and lands open to the public. Beyond the NAFB Bombing and Gunnery range land, land uses to the east of the NTS are primarily mining, grazing, and agriculture (BLM 1990; DOE/NV 1993a).

There are no onsite areas that are subject to Native American Treaty rights or contain any prime or unique farmland.

4.3 Socioeconomics

4.3.1 Region of Influence

The socioeconomic information presented in this Programmatic Environmental Impact Statement (PEIS) discusses the baseline conditions in a Region of Influence comprising of Nye and Clark Counties, Nevada. This is the region potentially affected by the principal direct and indirect socioeconomic effects of actions on the NTS. This Region of Influence includes the current residential distribution of the U.S. Department of Energy (DOE) and contractor personnel employed by the NTS, the probable location of offsite contractor operations, and the probable location of labor and capital supporting indirect economic activity linked to the NTS.

The residential distribution of most of the DOE and contractor personnel employed by the NTS reflects existing commuting patterns and attractiveness of area communities. A survey of NTS worker residential distributions in 1988 revealed that 86 percent lived in Clark County and 10 percent in Nye County (DOE 1988a). In Clark County, most NTS employees reside in the Las Vegas vicinity.

The two-county Region of Influence includes several communities located within a driving time of approximately 1 hour from the NTS, including Boulder City and the Las Vegas Valley (includes the "incorporated places" of Henderson, Las Vegas, and North Las Vegas; and the "census-designated places" of East Las Vegas, Enterprise, NAFB Bombing and Gunnery Range, Paradise, Spring Valley, Sunrise Manor and Winchester) in Clark County, and Pahrump and Beatty in Nye County (DOE/NV 1993a,b).

4.3.2 Regional Economic Activity and Population

Regional economic linkage supporting production activity at the NTS occurs primarily with Clark County, where most of the offsite supporting contractors and the labor and capital supporting indirect economic activity linked to the NTS are located.

4.3.2.1 Clark County (Las Vegas Metropolitan Statistical Area(1)). Clark County is

composed of five incorporated cities (Las Vegas, Henderson, North Las Vegas, Boulder City, and Mesquite) and large expanses of unincorporated land, some of which are experiencing strong growth. The area experiencing the majority of the county's development is the Las Vegas Valley (ULI 1992). In addition, 95 percent of the total area within the county is owned by the Federal government and includes several state parks, vast stretches of desert, and military installations.

Economic conditions in southern Nevada since the mid-1980s have grown continuously. Economic growth has accelerated relative to national trends due to an expansion in hotel and gaming markets, relocation of retirees to southern Nevada, expansion of local infrastructure, and additional unplanned investment to house new families in the region. The overall long-term growth pattern is forecasted to gradually change the current robust expansion to more stable growth conditions, as seen in the United States (The Center for Business and Economic Research 1992).

The economy in the Las Vegas Metropolitan Statistical Area is driven by growth in the hotel and gaming industry. Because of its orientation toward tourism and conventions, the economy is highly service oriented. Service employment in the Las Vegas area is substantially higher than the relative national share, accounting for nearly 45 percent of total employment, with hotels and gaming accounting for approximately 30 percent of the service factor. Trade employment accounts for 21 percent, and government and construction each account for an additional 10 percent (ULI 1992). Construction employment has increased over 130 percent since 1980, with 32,000 jobs in that sector in 1993 particularly due to the building and expansion of a number of casinos in Clark County (DOE/NV 1993a). The industrial market has also induced growth in the construction sector, causing a 50 percent increase in new construction activity between 1990 and 1992. Growth in the industrial market is expected to continue, with demand outpacing new construction (ULI 1992). Manufacturing employment is increasing steadily (7 percent from 1992 to 1993); however, this sector comprises only a 2.8 percent share of total employment (DOE/NV 1993a), still well below the national average.

Between 1980 and 1990, Clark County added an average of 15,000 jobs per year. By year-end 1991 another 19,000 jobs had been added to the employment base for 1990, for a total of 388,000 jobs (ULI 1992). In September 1992, employment in the Las Vegas area reached 399,900. Despite the national recession during 1990-1992, the number of existing jobs in the Las Vegas area increased rapidly, averaging an 8.1 percent gain during that period (DOE/NV 1993a).

The number of existing jobs in the Las Vegas area is projected to continue increasing for the next several years. The State of Nevada Employment Security Research Department estimated there would be a total of 125,190 new jobs in the Las Vegas area between 1991 and 1996, an increase of approximately 6 percent annually (DOE/NV 1993a).

The unemployment rate reached a low of 4.9 percent in 1990 and increased to 7.5 percent as of June 1993 (DOE/NV 1993a). The increase in unemployment reflected the fact that the in-migration of labor exceeded the growth in employment opportunities. However, the unemployment level is expected to decrease with new hotel, gaming, and amusement properties opening at the end of 1993 (DOE/NV 1993a).

Most of the population in the Las Vegas Metropolitan Statistical Area is centered in the

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1. At the time of the 1990 census, CLark County and the Las Vegas Metropolitan Statistical Area were synonymous. The Census Bureau redifined the Las Vegas Metropolitan Statistical Area to include Mohave County, Arizona. However, the numbers provided here reflect the 1990 census definition.

Las Vegas Valley, with six population groupings in the area: the Las Vegas Valley, Boulder City, Indian Springs, Laughlin, Mesquite, and the Moapa Valley (DOE/NV 1993b). In 1990, the population of the metropolitan statistical area totaled 735,000, growing at a rate of 4.7 percent annually from 1980 (ULI 1992). This rate of growth, however, is lower than that near the end of the 1980s. The population of the metropolitan statistical area was estimated at over 900,000 as of August 1993, an increase of nearly 8 percent annually since 1990 (DOE/NV 1993b).

4.3.2.2 Nye County. The employment level in Nye County (11,310 jobs) is low relative

to Clark County, and includes opportunities in the services, mining, and government sectors (DOE/NV 1993b).

Nye County is sparsely populated, with the two largest population groupings being in the unincorporated communities of Pahrump and Tonopah. The populations of Pahrump and Tonopah in 1990 were 7,424 and 3,616 (62 percent and 20 percent of the county total), respectively (DOE/NV 1993b).

Tourist (and business traveller) activity is an important part of the Nye County economy in communities along U.S. Route 95; however, in each community, mining is the major, even dominant, economic force.

In the 1970s and 1980s, nuclear weapons testing at the NTS dominated the Nye County economy when described in terms of employment by place of work. Most of the NTS work force commutes to Mercury or forward areas from the Las Vegas Valley, and most food and other services are provided at federally subsidized facilities onsite. However, some Nye County businesses do provide NTS support services. In the context of the Yucca Mountain repository oversight program, Nye County and DOE have engaged in efforts that could lead to greater employment and procurement opportunities for Nye County residents and businesses (NEEDA 1993).

4.3.2.3 Nevada Test Site. The NTS work force supports engineering design,

construction, and operation of the site and includes people employed by DOE and people employed by DOE contractors. The total NTS work force in 1993 included nearly 4,000 jobs located at the NTS and an additional 5,000 jobs in the Nevada Operations Office (DOE/NV 1993a). As of January 1994, the work force totaled 8,563 (3,286 on NTS, 3,805 in Las Vegas, and 1,472 in the rest of Nevada or other areas). There is currently no SNF-related employment at NTS (DOE/NV 1994a).

4.3.2.4 Aggregate Regional Economic and Demographic Baseline. For the purposes of

establishing a regional baseline to assess potential impacts for the programmatic analyses in Section 5.3, regional economic and demographic data for Clark and Nye counties were aggregated to form one region (Table 4.3-1).

The total population of this Region of Influence is projected to be 998,093 persons in 1995 and to grow at an annual average rate of 2.7 percent, reaching 1,281,666 persons in 2004. The labor force of the Region of Influence is projected to grow at an annual average rate of 3.1 percent, reaching 792,309 persons in 2004. The total employment in the Region of Influence is projected to grow at an annual average rate of approximately 3.1 percent from 552,439 jobs in 1995 to 734,589 jobs in 2004.

4.3.3 Public Service, Education and Training, and Housing Infrastructure

4.3.3.1 Police and Fire. The NTS's fire protection capacity is structured to accommodate

current mission requirements, with a self-contained firefighting department responsible for suppression and prevention. Other services include rescue, hazardous material response, training of fire personnel, fire prevention inspections, installation of all fire extinguishers at the NTS, and fire prevention awareness programs. In addition, the DOE has signed an agreement whereby the Nye County Fire Department will assist the Clark County Fire Department in case of an emergency at the NTS (DOE/NV 1993a).

The Las Vegas Fire Department is spending $9.7 million to build three new fire stations in the northwest area of the city to support growing public service demand in this area. The Clark

Table 4.3-1. Aggregate regional economic and demographic indicators for the NTS.

Years	Regional employment	Regional labor force	Regional population
1995	552,439	595,851	998,093
1996	573,279	618,329	1,033,234

1997	594,916	691,666	1,069,422
1998	617,450	665,968	1,107,037
1999	640,822	691,175	1,145,711
2000	665,060	717,317	1,185,766
2001	681,956	735,538	1,209,316
2002	699,258	754,197	1,233,372
2003	716,971	773,299	1,257,672
2004	734,589	792,309	1,281,666
2005	752,356	811,483	1,305,461
Average Annual Growth Rate	3.1%	3.1%	2.7%

a. Sources: Nye County Board of Commissioners (1993); The Center for Business and Economic Research (1992).

Note: Aggregate region includes Clark and Nye Counties. Labor force projection developed for this study.

County Fire Department plans to add two new fire departments within the next 5 years. There is a mutual agreement between the Clark County Fire Department and all surrounding area departments to assist in any fire emergency when necessary (DOE/NV 1993a).

Law enforcement at the NTS is provided by the Nye County Sheriff. Security enforcement, established to accommodate the requirements of NTS's mission, is the responsibility of a private contractor. Regional law enforcement services are provided principally by the Las Vegas Metropolitan Police Department. Las Vegas ranks fourth nationally in metropolitan statistical areas in police per capita, with 1 per 277 population (DOE/NV 1993a).

4.3.3.2 Health Care. The NTS has a self-contained medical center that provides limited

emergency treatment. Health care in the Las Vegas metropolitan area is provided through 13 full-service hospitals, with 3.44 hospital beds per 1,000 population. A major proposed health care facility is scheduled to open in 1994 to accommodate demand (DOE/NV 1993a).

4.3.3.3 Education and Training. The Clark County School District provides education

services for the families of the majority of the employees who work at the NTS. Enrollment in the Clark County School District was approximately 122,000 student in 1992 and was projected to be 136,000 students in 1993. An average student/teacher ratio of 22.32 is reported for elementary school grades K-6; the student/teacher ratio is not reported for other grades (DOE/NV 1993a).

Higher education and training resources provided by the NTS include the support provided by the DOE Contractor Education and Training Departments, with technical training in areas such as Radiation Protection Training, Radiological Response Training, Environmental and Health Training (which includes Hazardous Waste, Site Operation, and Emergency Response) to support NTS's mission. In addition, there are a number of vocational, training, and higher education institutions in the Las Vegas metropolitan area (DOE/NV 1993a).

Since 1990, southern Nevada has experienced tremendous growth in school enrollment. To accommodate the influx of students, the school district was able to negotiate the largest bond sale in Nevada history along with regular allocations from the Nevada legislature (DOE/NV 1993a).

4.3.3.4 Housing. Between 1980 and 1990, the number of housing units in Clark County

increased by 84 percent, from approximately 174,000 to approximately 320,500. The housing market continues to flourish, as the demand for new housing has consistently exceeded the supply (ULI 1992). The increase in demand is attributable to the influx of retirees and other in-migrant population.

Residential building permits, which peaked in 1988 at 26,400 units, declined to 13,500 units in 1991. Between 1991 and 1995, the number of permits issued is expected to average 15,000 units per year (ULI 1992). Demand is projected to outpace supply over the next 5 years, given the strong projections for population and employment (ULI 1992).

4.4 Cultural Resources

4.4.1 Archaeological Sites and Historic Structures

For approximately 12,000 years, people have inhabited the lands now comprising the NTS site. The availability of surface water was the primary determinant governing the location of past human occupation on these lands. On what is now the NTS, access to surface water was through springs located in canyons and at the bases of mountains and mesas. Therefore, there is very little evidence of human occupation in valleys or playas where surface water sources were unavailable, including the Frenchman Flat area where the proposed SNF site would be located (DOE/NV 1993b).

Three cultural resource surveys were conducted in the vicinity of the proposed site. Two archaeological sites were recorded but neither was considered potentially eligible for listing on the National Register of Historic Places (DRI 1991, 1989, 1987). As a result, no prehistoric or historic resources are expected to be located on the proposed SNF site.

4.4.2 Native American Resources

The Southern Paiute and Shoshone Native American tribes are known to have inhabited southern Nevada including parts of what is now the NTS. These tribes are known to be affiliated with sites located in the northern portions of NTS including the Pahute and Rainier Mesas. However, no known Native American resources are located within the proposed SNF site (DRI 1986a).

4.4.3 Paleontological Resources

The NTS is characterized by alluvium-filled, topographically closed valleys surrounded by ranges composed of Paleozoic sedimentary rocks and Tertiary volcanic tuffs and lavas. Although igneous rocks do not contain fossils, the deposits might contain late Pleistocene terrestrial vertebrate fossils (Sandia National Laboratories 1982).

4.5 Aesthetics and Scenic Resources

Visual or scenic resources comprise the natural and manmade features that give a particular environment its aesthetic qualities. These features form the overall impression that a viewer receives of an area or its landscape character.

Scenic resources at the NTS are set in a landscape which is a transition area between the Mojave Desert and the Great Basin, with vegetation ranging from grasses and creosote bush in the lower elevations to juniper, pinyon pine and sagebrush in elevations above 5,000 feet (1,524 meters) (DOE/NV 1993b). The topography of the NTS consists of a series of mountain ranges arranged in a north-south orientation separated by broad valleys (DOE/NV 1993b). The topography is also characterized by the presence of numerous craters produced by past nuclear testing at the NTS. Of the three principal valleys located within the NTS, Frenchman Flat surrounds the proposed location of the SNF site (BLM 1990). Access to the NTS is from U.S. Route 95, which runs in an east-west direction along the south side of the NTS at Mercury Valley (BLM 1990). The Mercury Highway, which runs north from the Mercury Base Camp, is a restricted access road that is not available for public access (Figure 2.1-2).

The proposed SNF site at the NTS is set along the east side of the Mercury Highway in Area 5, within the Frenchman Flat. The proposed SNF site is located in the vicinity of the existing Radioactive Waste Management Site. The land cover in this area is typical desert vegetation.

The viewshed surrounding the NTS consists of unpopulated to sparsely populated desert and rural lands. Since the NTS is surrounded to the east, north and west by the NAFB Bombing and Gunnery Range and to the south by lands controlled by the BLM, the only public views into the interior of the NTS are from U.S. Route 95. Since the southern boundary of the NTS is ringed by various mountain ranges, including the Spector Range, Striped Hills, Red Mountain, and the Spotted Range, views to the interior of the site are generally limited to the Mercury Valley and the Mercury Base Camp (BLM 1990).

Low sensitivity exists when the public can be expected to have little or no concern about changes in the landscape. Little value may be ascribed to the views, or they may be similar to others in the area. In general, due to the mixture of industrial uses, open desert, and restricted access, the NTS could be classified as having low visual sensitivity.

4.6 Geologic Resources

This section provides a description of the general geology, geologic resources, and seismic and volcanic hazards at the NTS and surrounding area. This section also describes any existing impacts to the geology and geologic resources that have resulted from past and present activities conducted at the NTS.

4.6.1 General Geology

As shown on Figure 4.6-1, the NTS is located east and north of the Walker Lane-Las Vegas Valley Shear Zone (Eckel 1968). Walker Lane is a northwest-trending belt of right-lateral faults that disrupts the regional structural grain in the southwestern part of the Great Basin along the California-Nevada border. The Las Vegas Valley shear zone is a concealed zone of right-lateral faulting along the north side of the Las Vegas Valley (DOE 1988b). Whether the Walker Lane-Las Vegas Valley Shear Zone comprises a continuous single fault or two faults is debatable. Most geologists consider it to be a single fault system, which in the NTS area is buried beneath Figure 4.6-1. Location of Nevada Test Site in relation to regional fault zones. thick Tertiary strata (Eckel 1968). The NTS also lies in the southern part of the Great Basin Section of the Basin and Range Physiographic Province. The local geology of the NTS is characterized by mountain ranges composed of Precambrian and Paleozoic sedimentary rocks and Tertiary volcanic tuffs and lavas that surround alluvium-filled, topographically closed valleys.

A generalized stratigraphic column of the area is shown on Figure 4.6-2 (Sandia National Laboratory 1982). Figure 4.6-2 also shows the six aquifers and four aquitards of the NTS area (see Section 4.8). A schematic cross section illustrating NTS geology is shown on Figure 4.6-3 (DOE 1986). A geologic map of the NTS is shown as Figure 4.6-4 (DOE/NV 1993b).

The sedimentary rocks are complexly folded and faulted and are comprised mainly of carbonates (dolomite and limestone) in the upper and lower parts of the column and clastics (shale and sandstone) in the middle section. Above the approximately 4,000 meters (13,000 feet) of Precambrian to Cambrian clastic deposits are approximately 4,300 meters (14,000 feet) of Cambrian through Devonian carbonates, 2,400 meters (8,000 feet) of Mississippian shales and sandstones, and 900 meters (3,000 feet) of Pennsylvanian to Permian limestones (Sandia National Laboratory 1982).

The volcanic rocks in the NTS area are predominantly Tertiary tuffs that are high in silica. Although there are minor amounts of Tertiary basalts and a few scattered Mesozoic granitic plutons in the area (Sandia National Laboratory 1982), the Tertiary tuffs comprise approximately 70 percent of the rocks exposed at the surface (Eckel 1968).

The valleys formed between steeply dipping faults that have become filled with alluvium and comprise approximately 30 percent of the area (Eckel 1968). This generally unconsolidated alluvium is derived from erosion of nearby hills composed of Tertiary and Paleozoic rocks and ranges in thickness from 600 to 900 meters (2,000 to 3,000 feet) (DOE/NV 1992c). Some layers are cemented by calcium carbonate (caliche) and/or clays. The alluvial materials are better sorted and finer grained toward the center of the basins. The sediments in the playas (flat-floored undrained desert basins that, at times, become shallow lakes) consist of very fine-grained lacustrine deposits up to several tens of meters (feet) thick. Near the range fronts, alluvium is generally composed of angular rubble, with individual clasts commonly a foot or more in diameter surrounded by a matrix of silt, sand, and gravel (Sandia National Laboratory 1982).

Figure 4.6-2. Stratigraphic column of the Nevada Test Site. Figure 4.6-3. Schematic cross section portraying the geologic complexity of NTS. Figure 4.6-4. Geologic map of the NTS.(page 1) Figure 4.6-4. Geologic map of the NTS.(page 2) Faulting in the NTS area generally occurs as thrust faults (faults having shallow inclinations, mostly between 10 and 20 degrees), normal faults (faults with downward displacement of the face of the rock that lies above the fault), and strike-slip faults (nearly vertical faults characterized by shear zones) (DOE/NV 1992c). The faults located at NTS are shown on Figure 4.6-5 (DOE/NV 1993b). Thrust faulting in the NTS area occurs as three major thrust faults, with the total displacement along this fault system ranging from 40 to 48 kilometers (25 to 30 miles). Normal faults in the NTS area exist in both ranges and valleys and generally strike northeast and northwest, while a set of younger and potentially active faults strike north. The nearest strike-slip structure to the NTS is the Walker Lane-Las Vegas Valley Shear Zone (see Figure 4.6-1). Estimates of horizontal displacement along this shear zone range from 40 to 160 kilometers (25 to 100 miles) (Sandia National Laboratory 1982).

At the NTS, recent displacement has occurred along several faults as a consequence of underground nuclear explosions. This displacement is not attributable to naturally occurring seismic activity. Fault displacements are thought to have occurred as a result of the added stress produced by the explosion, the vibrations produced by the explosions, or a combination of both (Eckel 1968).

Faults are designated as capable if they have exhibited movement at or near the ground surface at least once within the past 35,000 years or movement of a recurring nature within the past 500,000 years (CFR 1993a). Almost all of the natural fault movement in the NTS area occurred several million years ago. However, movement along Yucca Fault, a north-south striking fault known in the northeast portion of the NTS (see Figure 4.6-5), is believed to have occurred sometime during the last tens of thousands to 250,000 years (Leedom 1994; Sandia National Laboratory 1982). Given the broad range of time during which displacement along Yucca Fault is believed to have occurred, Yucca Fault may or may not be an NRC capable fault (Leedom 1994).

4.6.2 Geologic Resources

Gold, tungsten, and molybdenum may exist in carbonate rocks near igneous intrusions, regional thrust faults, or other faults at the NTS. In other areas, these deposits have been found

Figure 4.6-5. Approximate location of proposed facility in relation to major faults at NTS.

in carbonate rocks associated with this type of terrane. However, based on available information, the NTS is assessed as having only a low to moderate potential for the occurrence of tungsten skarn (contact metamorphic rock rich in iron) deposits and/or polymetallic replacement deposits, and very low potential for the discovery of gold in these types of rocks. Magnetite deposits exist in rocks at the NTS, but they are not extensive and have very low resource potential. Figure 4.6-6 shows the possible location of the SNF storage facility in relation to the types of terrains associated with geologic resources as well as to locations of mining districts (USAF et al. 1991).

Gold and silver may exist at NTS in Tertiary volcanic rocks or in sedimentary rocks near volcanic or intrusive centers. Based on limited information, however, NTS is assessed as having a low to moderate potential for the development of precious metal deposits in these rocks. It is estimated that one small to medium-sized precious metals deposit might have been developed within the NTS had the area remained open to mineral development (USAF et al. 1991).

Much of the alluvial areas along the lower flanks of the ranges within the NTS contain sand and gravel reserves. These materials, however, do not have any unique value over similar material occurring in other areas throughout southern Nevada (USAF et al. 1991).

Zeolitized rocks (various hydrous silicates occurring as secondary minerals in cavities of lavas) underlie most of the volcanic rocks and the alluvial basins at the NTS. Clinoptilolite and mordenite, either alone or in mixtures, are the most common zeolites in these deposits, but ferrierite, chabazite, and analcime also occur. Zeolite deposits in Nevada that have been developed for exploitation are lakebed deposits that have been altered to zeolites under saline water-saturated conditions. Zeolites are used in water softeners, detergent builders, and cracking catalysts. Very little information is available on the tonnage and grade of these deposits. The widespread occurrence of zeolite deposits, however, requires that the deposits at NTS be assigned a low to moderate potential for development (USAF et al. 1991).

Barite is also known to occur at the NTS. The barite occurs in veins associated with quartz and mercury, antimony, and lead mineralization. These veins cut Devonian carbonate rocks. However, the barite veins at the NTS are small and impure, and do not represent a potential barite resource (USAF et al. 1991).

Figure 4.6-6. Geologic terrains and mining districts of the Nevada Test Site.

Fluorite is also reported to be present at the NTS, occurring in veins and replacement bodies within Paleozoic sedimentary rock. However, little is known about this occurrence; therefore, the NTS is assumed to have a very low to moderate potential for the development of fluorite resources (USAF et al. 1991).

4.6.3 Seismic and Volcanic Hazards

The NTS lies on the southern margin of the Southern Nevada East-West Seismic Belt. This belt connects the north-trending Nevada Seismic Belt, about 160 kilometers (100 miles) west of the site with the north-trending Intermountain Seismic Belt about 240 kilometers (150 miles) to the east. The location of these seismic belts are shown on Figure 4.6-7. The pattern of historic earthquakes in the western United States is marked by relatively brief episodes of intense activity in areas that may have been relatively inactive for hundreds and perhaps thousands of years (DOE 1986).

The southern Nevada region is generally characterized as an area of moderate seismic activity (DOE/NV 1993b). The proposed SNF management site is located on the eastern NTS in a region considered to have a moderate seismic-activity level. Earthquakes in southern California and the California desert have registered on the NTS seismic network.

Prior to the installation of a seismic network within a 160-kilometer (100-mile) radius of the site in 1978 and 1979, 12 earthquakes (including one series of earthquakes) with Richter magnitudes (M) of equal to or greater than 6.5 were reported within a 400-kilometer (250-mile) radius of the site (DOE/NV 1994b). One of the largest and nearest of the earthquakes relative to NTS was the 1872 Owens Valley shock (M = 8.25), located approximately 150 kilometers (100 miles) from the site. Figure 4.6-8 shows the location of the pre-network earthquakes with M greater than or equal to 5 that have occurred near the NTS (DOE 1988b). Recorded seismic activity prior to 1978 in the vicinity of the NTS also includes two earthquakes with M equals 4.3 and M equals 4.5 near Massachusetts Mountain (located just north of the proposed SNF storage site) and in Frenchman Flat (located in the southeast corner of the NTS, an area that includes the proposed SNF storage site) (DOE/NV 1994b).

Figure 4.6-7. Location of the NTS in relation to the Nevada Seismic Belt, the Intermountain

Seismic Belt, and the Southern Nevada East-West Seismic Belt.

Figure 4.6-8. Historical Seismicity of the Southern Great Basin from 1868 through 1993 for M>5.

Between 1978 and 1981, no earthquakes with magnitudes greater than 4.3 were recorded. Since 1981, a magnitude 5.6 earthquake was recorded near Little Skull Mountain (located near the southwest corner of the NTS) in 1992 at a depth of 12 kilometers (7.5 miles). In 1993, a magnitude 3.5 earthquake was recorded southeast of the town of Mercury on the NTS (DOE/NV 1994b). However, there is some uncertainty in the seismic sources for many signals recorded by the seismic monitoring network in the area, because underground nuclear explosions, surface drilling, and explosions to support geophysical investigations may produce earthquake-like signals (DOE 1986).

The most probable source for seismic activity within the area where the SNF storage facility would be located is the Cane Spring Fault (see Figure 4.6-5). This fault is thought to be the source of the magnitude 4.3 Massachusetts Mountain earthquake discussed above. The maximum credible earthquake associated with the Cane Springs Fault is expected to be a magnitude earthquake of 6.7. The recurrence interval for this magnitude earthquake is estimated at 10,000 to 30,000 years (DOE/NV 1993a).

Predictions of future seismicity and faulting, however, are complicated by a number of factors. Because the recurrence interval for large earthquakes on a Basin and Range fault may be thousands of years, epicenter maps of historic earthquakes or evidence of Holocene faulting alone may not be reliable indicators of future or long-term seismicity. Another complication is that when long fault zones in normal fault regimes fail, they may break along segments rather than along the entire length. Large (M greater than 7) earthquakes in the western Great Basin tend to be followed by aftershocks lasting about a century and then seismic activity stabilizes at a low level for centuries or thousands of years. Based on this concept, recurrence estimates based on historic or current earthquake distributions may not be directly applicable to the problem of identifying the most likely locations of future large earthquakes (DOE 1986).

From the historical seismicity of the southern Great Basin (two earthquakes of M equals 6) and length of active faults, a maximum magnitude of M equals 7 to 8 is inferred for earthquakes in the Yucca Mountain region. Estimates of recurrence intervals for major earthquakes in the region (M is greater than or equal to 7) are on the order of 25,000 years; for magnitudes of greater than or equal to 6, recurrence intervals are on the order of 2,500 years; and for magnitudes of greater than or equal to 5, recurrence intervals are on the order of 250 years (DOE 1986).

Ground motion acceleration resulting from earthquakes may cause damage to buildings and other structures. Ground motion acceleration is represented by the unit (g), which is the acceleration due to the force of the earth's gravitational field and is approximately equal to 986 centimeters per square second (DOE/NV 1993a). A maximum horizontal ground surface acceleration of 0.34g at the NTS is estimated to result from an earthquake that could occur once every 2,000 years (DOE 1994). The seismic hazard information presented in this EIS is for general seismic hazard comparisons across DOE sites. Potential seismic hazards for existing and new facilities should be evaluated on a facility specific basis consistent with DOE orders and standards and site specific procedures.

The Massachusetts Mountain earthquake associated with the Cane Spring Fault (the most probable source for seismic activity in the area of the proposed SNF storage facility) discussed above occurred on August 5, 1971 and produced a peak ground motion acceleration of 0.05 g. The maximum credible earthquake associated with the Cane Spring Fault is expected to produce a peak acceleration of 0.67 g (DOE/NV 1993a).

Volcanic activity in the area is evident in the geologic record by the presence of widespread tuffs and scattered granitic plutons deposited during the Tertiary period and basalts deposited during the late Pliocene and Pleistocene epochs (DOE 1988b).

The potential for renewed silicic volcanism is suggested by the youngest (7- to 8-million year old) major silicic volcanic center in the area, the Black mountain center, located just west of the northwest corner of the NTS. However, the occurrence of silicic volcanism near the NTS during the next 10,000 years is considered unlikely due to: no silicic volcanism in the south-central Great Basin during at least the past 6 million years, the decrease of silicic volcanism throughout the central and southern parts of the Great Basin during the past 10 million years, and the restriction of silicic volcanism to the margins of the Great Basin during the Quaternary (the past 2 million years). If silicic volcanism were to occur, the most likely effect at NTS would be the deposition of air-fall tuff from eruptions of silicic centers near the western margin of the Great Basin, as happened at least twice during the Pleistocene. Such volcanism could result in the deposition of fine-grained volcanic ash in layers ranging from a few millimeters to tens of centimeters thick (DOE 1988b).

The possibility of future basaltic volcanism near the NTS is suggested by Quaternary basaltic volcanism, notably in the Crater Flat basalt field, just west of the southwest corner of the NTS. However, future basaltic eruptions would likely be small and short-lived judging from the Quaternary record of basaltic volcanism due to: magma volumes for eruptions in the vicinity of the NTS during the past 8 million years being generally less than 1.0 x 108 cubic meters (3.5 x 109 cubic feet), and of short duration; a low rate of magma generation in the south-central Great Basin during the late Cenozoic as reflected by the small-volume, basalt eruptive cycles in the region; and the lack of geologic or geochemical patterns indicating that the rates of volcanism in the southern Great Basin are increasing, that such rates might increase in the future, or that basaltic activity could evolve into more voluminous types of basalt fields. The probability for the penetration of a repository at Yucca Mountain by basaltic volcanism was calculated based upon studies of volcanic deposits in the vicinity. According to these calculations, the annual probability is estimated as 3.3 x 10-10 to 4.7 x 10-8 (DOE 1988b).

4.7 Air Resources

Because the transport of airborne effluents is affected by meteorological conditions, the climatology at the NTS is discussed in this section. A summary of air monitoring networks is then included. Finally, the most recent air quality data available are presented.

4.7.1 Climatology

The climate at the NTS and the surrounding region is characterized by high solar radiation, limited precipitation, low relative humidity, and large diurnal temperature ranges. The lower elevations have a climate typical of the Great Basin.

NTS is situated at the edge of the Mojave Desert, and the arid climate is typical of the Great Basin. The Sierra Nevada Mountains of California and the series of mountains exceeding 1,830 meters (6,000 feet) in height immediately west and north of the NTS have a marked influence on the climate. The prevailing upper level winds are from the west; most of the moisture associated with Pacific Ocean storms falls on the western slopes of the Sierra Nevada. East of the Sierra Nevada, at locations such as the NTS, very little precipitation occurs.

The Weather Services Office at the NTS monitors meteorological data from numerous observation sites within and in the vicinity of the NTS. The nearest National Weather Service full-time meteorological monitoring station is at McCarran International Airport, Las Vegas.

At Area 6 of the NTS, the average daily maximum/minimum temperatures during the month of January are 10.6yC/-6.1yC (51yF/21yF). The average daily maximum/minimum temperatures are 35.6yC/13.9yC (96yF/57yF) in July. At Las Vegas, the coldest temperature on record is -13.3yC (8yF) and the warmest temperature on record is 46.7yC (116yF).

The average annual precipitation at Area 6 is 15 centimeters (6 inches). Precipitation amounts for each month are generally less than 1.3 centimeters (0.5 inch). At Las Vegas, the greatest precipitation recorded in a 24-hour period is 6.6 centimeters (2.59 inches). An average of 14 thunderstorm days occur each year, with maximum occurrence in July and August. Thunderstorms occasionally become severe. Tornadoes are extremely rare in Nevada. The average relative humidity at 4 AM in Las Vegas is 40 percent. The average relative humidity at 4 PM is 20 percent.

Low-level surface winds at the NTS are influenced by the large-scale weather patterns interacting with the mountain ranges, which generally run from north to south. Predominant winds are from the south during the summer and north during the winter. The general downward slope in the terrain from north to south across the NTS results in a diurnal wind reversal from the south during the day to the north during the night. At Area 6, the average annual wind speed is 11 kilometers per hour (7 miles per hour). Occasionally, strong winds associated with storms will exceed 82 kilometers per hour (50 miles per hour). These events are most common in the spring. At Las Vegas, the peak wind gust on record is 145 kilometers per hour (90 miles per hour). Strong winds interacting with dry soil conditions are responsible for occasional duststorms or sandstorms.

Wind direction and speed are major factors in planning and conducting nuclear tests, where atmospheric transport is the primary potential route of contamination to onsite workers and offsite populations. Figure 4.7-1 presents 10-meter (33-feet) wind roses for the NTS in 1990. A wind rose presents the frequency distribution of wind directions at a particular location. The wind roses indicate that there are differences in prevailing wind directions across the NTS. Mountain slopes and valleys are major determinants in these localized variations (DOE/NV 1993c; National Climatic Data Center 1991).

Atmospheric dispersion improves as the wind speed increases, conditions become more unstable, and the depth of the mixing height increases. The transport and dispersion of airborne material are direct functions of air movement. Transport directions and speeds are governed by the general patterns of air flow (and by the nature of the terrain), whereas the diffusion of airborne material is governed by small-scale, random eddying of the atmosphere (i.e., turbulence). Turbulence is indicated by atmospheric stability classification. Data collected at Desert Rock for calendar year 1990 indicated that atmospheric conditions were unstable (i.e., Stability Classes A through C) approximately 25 percent of the time, neutral (Class D) approximately 37 percent of the time, and stable (Classes E through G) approximately 37 percent of the time for that year.

4.7.2 Air Monitoring Networks

4.7.2.1 Radiological Monitoring Network. DOE Order 5400.1, General Environmental

Protection Program, established the onsite environmental protection program requirements, authorities, and responsibilities for DOE operations. At the NTS, radiological effluents may originate from tunnels, underground test sites, and facilities where materials are used, processed, stored, or discharged. Airborne radiological effluents at the NTS have the greatest potential for reaching the public. There are two radiological monitoring programs for potential airborne radioactive effluents associated with the NTS, one onsite and the other offsite (DOE/NV 1993c). Figure 4.7-1. 1990 10-meter (33 foot) wind rose patterns for the NTS. The onsite environmental surveillance program consists of 52 air sampling stations collecting particulates and reactive gases; 17 samplers collecting atmospheric moisture for tritium analysis; 10 samplers collecting air samples for noble gas analysis; 63 water sampling locations that include wells, springs, reservoirs, and ponds onsite; and 187 locations where thermoluminescent dosimeters are positioned for measurement of external gamma exposures (DOE/NV 1993c).

The offsite radiological monitoring program is conducted around the NTS by the U.S. Environmental Protection Agency's (EPA's) Environmental Monitoring Systems Laboratory, Las Vegas, under an interagency agreement. This program consists of several extensive environmental sampling, radiation detection, and dosimetry networks. In 1992, the Air Surveillance Network was made up of 30 continuously operating sampling locations surrounding the NTS and 77 standby stations (operating one week each quarter) in all states west of the Mississippi River. During 1992, no airborne radioactivity related to current nuclear testing at the NTS was detected on any sample from this network (DOE/NV 1993c).

4.7.2.2 Nonradiological Monitoring Network. Nonradiological environmental monitoring

of NTS operations involved only onsite monitoring because there were no nonradiological hazardous material discharges offsite.

4.7.3 Air Releases

4.7.3.1 Radiological. The majority of radioactive effluents at NTS in 1992 originated

from underground nuclear tests designed and conducted by two national laboratories and the Defense Nuclear Agency. The Los Alamos National Laboratory of Los Alamos, New Mexico and the Lawrence Livermore National Laboratory of Livermore, California conducted tests in support of DOE nuclear testing program objectives. Sandia National Laboratories of Albuquerque, New Mexico supported tests conducted by the Defense Nuclear Agency, which uses the NTS as a nuclear testing facility under an agreement with DOE (DOE/NV 1993c).

The presence of plutonium as an airborne, radioactive effluent at NTS in 1992 is primarily due to previous atmospheric tests and tests in which nuclear devices were detonated with high explosives (called "safety shots"). These latter tests spread low-fired plutonium in the eastern and northeastern areas of the NTS. Three decades after the conclusion of the atmospheric test program, higher than normal levels of plutonium in the air are still detected in several areas. Because of operational activities and vehicular traffic in Area 3 some of the plutonium becomes airborne and elevated levels of plutonium have been detected in Area 3 for several years (DOE/NV 1993c).

Six underground nuclear tests were conducted at the NTS during 1992. A list of these tests and a summary of environmental monitoring observations for each of these are provided in Table 4.7-1.

Air emissions from nuclear testing operations consisted primarily of radioactive noble gases and tritium released during posttest drillback, mineback, or sampling operations following each of **the 1992 underground nuclear tests.** None of the tests resulted in a prompt release or venting (release of radioactive materials within 60 minutes of the nuclear test). Onsite radiological safety support included monitoring emissions during the six nuclear tests. Testing included detecting, recording, evaluating, and reporting radiological conditions prior to, during, and for an extended period after each test with provisions for aerial monitoring teams to detect airborne releases (DOE/NV 1993c).

Following each test, when control of the test area was released by the DOE Controller, survey personnel obtained radiation measurements using portable detection instruments. During the postevent drillback and mining activities, continuous environmental surveillance was maintained in the work area. For containment of radioactive releases to the atmosphere during drillback, systems were employed to trap radioactive particles.

Radioactive waste management sites are located in Areas 3 and 5. These sites serve as DOE defense waste disposal sites (DOE/NV 1993c).

NTS airborne radionuclide emissions for 1992 are presented in Table 4.7-2.

4.7.3.2 Nonradiological. Air emissions from the NTS originate from concrete batch plants, aggregate crushing and processing, surface disturbance, fire training exercises, motor

Table 4.7-1. Nuclear test release summary - 1992 at the NTS Site.

Event name	Test org.	Hole/ area no.	Location	Date/ time of event	Prompt release?	Telemetry measurement		Initial radiation sur		Maximum exposure rate	Release information
						Start	Stop	Began	Ended		
Junction	LANL	U19bg Area 19	Pahute Mesa	03/26/92 0830 hrs	No	03/26/92 0830 hrs	03/27/92 0830 hrs	03/26/92 1029 hrs	03/26/92 1108 hrs	0.05 mR/h	None detected
Diamond Fortune	DNA	U12p.05 Area 12	Rainier Mesa	04/30/92 0930 hrs	No	04/30/92 0930 hrs	05/11/92 1400 hrs	04/30/92 1109 hrs	04/30/92 1143 hrs	0.05 mR/h	Release included 0.242 Ci Xenon-133 and 6.05-Ci Iodine-131 (5/4/92 to 7/2/92) from low level seepage until cavity gases were transferred to Distant Zenith chimney
Victoria	LANL	U3kv Area 3	Yucca Basin	06/19/92 0945 hrs	No	06/19/92 0945 hrs	06/24/92 1500 hrs	06/91/92 1014 hrs	06/19/92 1040 hrs	0.05 mR/h	None detected
Galena	LLNL	U9cv Area 9	Yucca Basin	06/23/92 0800 hrs	No	06/23/92 0800 hrs	06/24/92 2200 hrs	06/23/92 0914 hrs	06/23/92 0923 hrs	0.05 mR/h	None detected
Hunters Trophy	DNA	U12n.24 Area 12	Rainier Mesa	09/18/92 1000 hrs	No	09/18/92 1001 hrs	09/22/92 1300 hrs	09/18/92 1116 hrs	09/18/92 1151 hrs	3.0 mR/h	Release of 0.9 Ci of noble gases and tritium (11/18/92 to 1/5/93) from diagnostic studies
Divider	LANL	U3ml Area 3	Yucca Basin	09/23/92 0804 hrs	No	09/23/92 0804 hrs	09/24/92 0941 hrs	09/23/92 0856 hrs	09/23/92 0915 hrs	0.05 mR/h	Release of 0.11 Ci Xenon-133 on 10/14/92 during post shot operations
Distant Zenith	DNA	U12p.04 Area 12	Rainier Mesa	09/19/91 0930 hrs	No	1992 releases associated with ventilation of LOS pipe and drilling in the Chimney region and included: 1.33 Ci85Kr, 2.07 Ci37Ar, and 0.1 -Ci39Ar					

a. Source: DOE/NV 1993c.

Table 4.7-2. Airborne radionuclide emissions for 1992 at the NTS.

Event or facility name (airborne releases)	Curies									
	Tritiumb	Argon-37c	Argon-39	Krypton-85	Xenon-127d	Xenon-129me	Xenon-131m	Xenon-133m	Iodine-131	Plutonium-239,240
Area 3, DIVIDER 1.1 x 10-1										
Area 3f 2.5 x 10-3										
Area 5, RWMSf	6 x 10-1									
Area 6g 1.3 x 10-5										
Area 12, N Tunnel	4.9 x 10-2	7.9 x 10-1	8.1 x 10-5	1.3 x 10-2	5.7 x 10-6	2.4 x 10-5				

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1.5 x 10-2   3.9 x 10-2
  P Tunnel       3.6 x 10-1   2.1 x 10-0                1.3 x 10-0
2.4 x 10-1   6.0 x 10-6
Area 19 and 20,
  Pahute Mesad
                                                        2.8 x 10+2
Total            1.0 x 10-0   2.9 x 10-0   8.1 x 10-5   2.8 x 10+2   5.7 x 10-6   2.4 x 10-5
1.5 x 10-2   3.9 x 10-1   1.9 x 10-5   2.5 x 10-3
```

a. Source: DOE/NV 1993c.

b. Total includes 4.9 x 10-2 Ci of molecular HT from Hunter's Trophy. Remainder is in the form of tritiated water vapor, primarily HTO.

c. Ar-37 with 35 day half-life not in GENII. Decays to stable Cy-37.

d. Xe-127 with 36.4 day half-life not in GENII. Decays to stable I-127.

e. Xe-127m with 8 day half-life not in GENII. Decays to stable Xe-129.

f. Calculated from air sampler data.

g. Assumes all radioactivity on Anti-C clothing is I-131 and all becomes airborne during drying.

vehicle operations, boilers, and fuel storage. The concrete batch plants, aggregate crushing and processing facilities, and surface disturbance activities are sources of particulate matter. These activities are largely intermittent and occur in support of specific testing programs on the NTS. Fire training exercises consist of periodic open burning in designated areas with approved fuel materials conducted by fire and emergency personnel several times per year. Motor vehicle operations and boilers are the largest sources of air pollutants at the NTS; motor vehicles consume gasoline, while boilers, construction equipment, and other diesel engines consume diesel fuel. A continuous, nonradiological air monitoring network is not in place at the NTS (USAF et al. 1991). Table 4.7-3 presents the maximum allowable nonradiological emission rates for those NTS sources which require permits.

4.7.4 Air Quality

4.7.4.1 Radiological. Onsite surveillance of airborne particulates, noble gases, and

tritiated water vapor indicated onsite concentrations that were generally not statistically different from background concentrations. External gamma exposure monitoring in 1992 indicated that the gamma environment within the NTS remained consistent with that of previous years. All gamma monitoring stations displayed expected results, ranging from the background levels predominant throughout the NTS to the types of exposure rates associated with known contaminated zones and radiological material storage facilities. Results of 1992 offsite environmental surveillance indicated no NTS-related radioactivity was detected at any air sampling station, and there were no apparent net exposures detectable by the offsite dosimetry network (DOE/NV 1993c).

The GENII environmental transport and dose assessment model (PNL 1988) was used to calculate the effective dose equivalents (EDE) resulting from the airborne radionuclide emissions presented in Table 4.7-2. These results are summarized in Table 4.7-4. The maximum EDE at the NTS boundary is 1.1 x 10-2 millirem. This is 1.1 x 10-1 percent of the corresponding National Emissions Standard for Hazardous Air Pollutants. The collective EDEs to the estimated population of 15,100 persons within 80 kilometers (50 miles) of the proposed SNF facility is 5.2 x 10-3 person-rem, which is 1.2 x 10-4 percent of the natural background radiation dose affecting this population. Background radiation doses are presented in Figure 4.7-2.

Table 4.7-3. Total nonradiological emission rates at NTS for permitted sources.

Pollutant	Emission rate (g/s)
Carbon monoxide	b
Nitrogen dioxide	b
Particulate matter (PM10)	2.8
Sulfur dioxide	4.5
Lead	b

a. Source: Engineering Science, Inc. (1990).

b. No pollutant sources indicated.

Table 4.7-4. Summary of effective dose equivalents to the public from NTS operations during 1992.

	Maximally exposed individual doseb	Collective dose to the population within 80 km of NTS sourcesc
Dose	1.1 x 10-2 mrem	5.2 x 10-3 person-rem
NESHAP standard	10 mrem per year	--
Percentage of NESHAP	1.1 x 10-1	--
Natural background dose	278 mrem per year	4190 person-rem per year
Percentage of natural background dose	4.0 x 10-3	1.2 x 10-4

a. Sources: 1992 Radionuclide emissions from DOE/NV 1993c GENII Model (PNL 1988) used to predict EDE. Natural background dose from DOE/NV 1993c.

b. The maximum boundary dose is to the hypothetical individual who remains in the open continuously during the year at the NTS boundary.

c. Based on an estimated population of 15,100 persons within 80 km of the proposed SNF facility in 1995.

Figure 4.7-2. Sources of radiation exposure, unrelated to NTS operations, to individuals in the vicinity of NTS.

4.7.4.2 Nonradiological. Air quality rules and regulations applicable to the NTS are governed by the Clean Air Act, the Nevada Revised Statutes, and the Nevada Administrative Code. The EPA administers the Federal regulations developed to implement the Clean Air Act, and the Nevada Department of Conservation and Natural Resources is responsible for enforcing the Federal and state regulations. Air quality in a given location is described as the concentration of various pollutants in the atmosphere, generally expressed in units of micrograms per cubic meter (-g/m3).

The Clean Air Act directed the EPA to set National Ambient Air Quality Standards (NAAQS) for those pollutants, termed criteria pollutants, that pose the greatest threat to air quality in the United States. The six criteria pollutants are ozone, carbon monoxide, sulfur dioxide, lead, nitrogen dioxide, and particulate matter with an aerodynamic particle diameter less than or equal to 10 microns, referred to as PM10. The Clean Air Act Amendments authorized the EPA to designate geographic regions not in compliance with NAAQS as nonattainment areas. The NTS is located within the Nevada Air Quality Control Region 147, which is in attainment with respect to the NAAQS for the criteria pollutants (CFR 1993b; Engineering Science, Inc. 1990). The nearest nonattainment areas to the Nevada Test Site Spent Nuclear Fuel site are in Clark County, which includes an area in the Las Vegas planning area that is designated serious for PM10 and an area in Las Vegas that is designated moderate for carbon monoxide (CFR 1993b).

Under the Clean Air Act, clean air areas are divided into classes. National parks and wilderness areas receive mandatory Class I protection. Very little pollution increase is allowed in Class I areas. The only Class I area in Nevada, the Jarbridge Wilderness Area, is located approximately 480 kilometers (300 miles) from the NTS, in the northwest corner of Nevada. The nearest Class I areas to the NTS are the Grand Canyon National Park, approximately 275 kilometers (171 miles) to the southeast, and Sequoia National Park approximately 175 kilometers (109 miles) to the west-southwest. The NTS is located in a Class II area, as are most areas across the country.

In addition to the criteria pollutants which are regulated under the National Ambient Air Quality Standards and under various emission standards, hazardous air pollutants are regulated. Title III of the Clean Air Act Amendments of 1990 directed the EPA to determine maximum available control technologies which would be used as the basis for emission limits for the hazardous air pollutants.

Engineering Science, Inc. of Pasadena, California conducted an air quality study at the NTS in 1990. The study examined air quality compliance of the NTS with applicable Federal and state air quality standards. The study encompassed an air emissions inventory, ambient air monitoring, and air pollution source testing at various sources. Based on the data collected at the ambient air monitoring stations established for the study, air quality at the NTS is within applicable Federal and state standards. The results of background monitoring performed by Engineering Science, Inc. are summarized in Table 4.7-5. This is the most recent comprehensive analysis of NTS ambient air quality.

Air dispersion modeling was performed to determine the maximum concentrations of the criteria pollutants. These results are also summarized in Table 4.7-5. The "total existing maximum concentrations" in Table 4.7-5 would result if all permitted sources at the NTS operated at the maximum allowable capacity. All pollutant concentrations from this worst-case scenario of existing emissions at the NTS are below applicable regulations.

4.8 Water Resources

This section provides a description of the surface water and groundwater at the NTS and surrounding area. The section also describes the existing impacts to surface water and groundwater that have resulted from past and present operations at the NTS.

4.8.1 Surface Water

The drainage basins and the generalized directions of surface water flow near the NTS are shown in Figure 4.8-1 (USAF et al. 1991). The boundary lines of the drainage basins occur principally along topographic divides (DOE 1988b). Figure 4.8-1 also shows other surface water features.

Table 4.7-5. Comparison of baseline concentrations with most stringent applicable regulations and guidelines at the NTS.

Criteria pollutant	Averaging time	Most stringent regulation or guideline (-g/m3)	Maximum background concentration (-g/m3)	Maximum existing DOE site contribution (-g/m3)	Total existing maximum concentration (-g/m3)
Carbon monoxide	8-hour	10,000	2,290	b	2,290
	1-hour	40,000	2,748	b	2,748
Nitrogen dioxide	Annual	100	c	b	b
Lead	Calendar quarter	1.5	c	b	b
Particulate matter (PM10)d	Annual	50	c	0.43	0.43
	24-hour	150	78.3	6.6	84.9
Sulfur dioxide	Annual	80	c	1.07	1.07
	24-hour	365	39.3	15.9	55.2
	3-hour	1,300	65.4	104.9	170.3
Hazardous air pollutants	b	b	b		b

a. Sources: Maximum background concentration provided by Engineering Science, Inc. (1990). Maximum existing DOE site contribution computed by Halliburton NUS.

b. No sources indicated.

c. Not measured.

d. All suspended particulate matter is assumed to be PM10.

Figure 4.8-1. NTS hydrologic basins and surface drainage direction.

Almost all stream flow in the NTS area is ephemeral, and therefore almost no streamflow data have been collected. The average annual runoff within the hydrographic areas in the Death Valley Basin in Nye County was estimated at less than 164 million gallons (620,000 cubic meters) per area (DOE 1988b).

The ephemeral character of streamflow has also limited the onsite monitoring of surface water quality. Water samples were, however, collected from the main channel of Fortymile Wash and two of its principal tributaries (Drill Hole Wash and Busted Butte Wash) during periods of runoff and flooding in 1984. Due to unknown factors such as compositional variability of storms, any quantitative interpretation is unwarranted (DOE 1988b).

Throughout the NTS, perennial surface water originates solely from springs, and it is restricted to source pools at some large springs. Because of the extreme aridity of this region, most of the spring discharge travels a short distance before evaporating or infiltrating back into the ground (DOE 1986). Thus, dry washes may be the principal sources of potential groundwater recharge inputs in the area (DOE 1988b). In addition, playas on NTS, including Frenchman Lake located in Area 5 and Yucca Lake to the northwest of Area 5, may retain standing water for hours to weeks following intense precipitation events. These playas represent the only natural surface water features in the vicinity of Frenchman and Yucca Flats. The direction of movement of water accumulated in playas is generally upward due to high evapotranspiration (DOE/OFE 1994). However, accumulated runoff in Frenchman Lake and Yucca Lake reportedly serves to recharge the valley fill aquifer (DOE 1988b).

Despite the arid climate, which includes high annual average potential evaporation, low average annual precipitation, and infrequent storms, surface runoff does occur. Runoff results from storms that occur most commonly in winter and occasionally in autumn and spring, and from localized thunderstorms that occur mostly during the summer (DOE 1988b). The ephemeral streams resulting from heavy precipitation fill the normally dry washes. Local flooding may occur where the water exceeds the capacity of the channels. In contrast to the washes, the terminal playas may retain standing water for days or weeks after severe storms (DOE 1986). Playas in Kawich Valley and Gold Flat collect and dissipate the runoff from the northern part of Pahute Mesa (ERDA 1977). Summer floods usually do not accumulate to cause regional floods, but their intensive character renders them potentially destructive over limited areas (DOE 1988b).

The western half and southernmost part of the NTS have channel systems which carry runoff beyond NTS boundaries during infrequent, very intense storms. Fortymile Canyon is the largest of these systems, originating on Pahute Mesa in the northwestern part of the NTS and draining into the normally dry Amargosa River channel about 20 miles (32 kilometers) southwest of the NTS. Within the NTS, Fortymile Canyon and its tributaries are restricted to well-incised canyons. Flood-prone areas surround Fortymile Wash, a major tributary within Fortymile Canyon. The other major NTS tributaries to the Amargosa River are Tonopah Wash, which runs southwesterly from Jackass Divide in the south-central part of the NTS into the Amargosa Desert near Amargosa Valley, and Rock Valley, which drains from the southernmost part of the NTS westward and then southward to Ash Meadows in the east-central portion of the Amargosa Desert (ERDA 1977).

The Amargosa River originates in Oasis Valley and continues southeastward through the Amargosa Desert past Death Valley Junction, then southward another 45 miles (82 kilometers), where it turns northwestward and terminates in Death Valley. The river carries floodwaters following cloudbursts or intense storms but is normally dry, except for a few short reaches that contain water from springs (DOE 1988b).

Two watersheds, Fortymile Canyon and Jackass Flats, have the potential of endangering offsite public health and safety due to flooding. Regional peak-flood flow equations for the southern Nevada area indicate that the 100-year peak flow from the Fortymile Canyon drainage is approximately 13,000 cubic feet (370 cubic meters) per second and 8,200 cubic feet (230 cubic meters) per second from the Jackass Flats drainage (USAF et al. 1991).

In summary, the potential exists for sheet flow and channelized flow through ephemeral washes from intense precipitation events to cause localized flooding throughout the NTS; however, no comprehensive floodplain analysis has been conducted on the NTS to delineate the 100- and 500-year floodplains associated with NTS drainages. No flood studies are known to have been conducted for the proposed SNF facility in Area 5; a flood assessment was conducted for the Radioactive Waste Management Site in NTS Area 5 on Frenchman Flat, located southwest of the proposed SNF Site. This study determined that the southwest corner of the Radioactive Waste Management Site is located in Federal Emergency Management Agency Zone AO (100-year flood zone with depths between 1 and 3 feet [0.3 and 0.9 meter]) of the Barren Wash Alluvial Fan. The remainder of the Radioactive Waste Management Site is located in Zone X of the Halfpint Alluvial Fan (100-year flood zone with depths less than 1 foot [0.3 meter]). Areas to the north, south, and east of the Radioactive Waste Management Site are in Zone X or Zone AO (DOE/NV 1993d). These suggest that the proposed SNF facility area may encompass areas in Zone X and/or areas in Zone AO associated with the Halfpint Alluvial Fan. Probable maximum flood analyses are known to have been performed only for areas in the vicinity of Yucca Mountain to aid in flood protection design for Yucca Mountain facilities (DOE 1988b).

Underground nuclear testing has resulted in the release of radioactive materials at the land surface. There is the potential for 100-year floods to transport these contaminants beyond the boundaries of the NTS. Quantitative estimates of this potential cannot be determined without additional studies (USAF et al. 1991).

There are no National Pollutant Discharge Elimination System (NPDES) permits for the NTS, as there are no wastewater discharges to onsite or offsite surface water. NTS sanitary wastewaters are discharged to sewage lagoons or to septic tank/leach field systems. All wastewater discharges at NTS are conducted in accordance with permits issued by the State of Nevada (DOE/NV 1993c).

4.8.2 Groundwater

Generally, the hydrogeology at the NTS is characterized by great depths to the groundwater table and slow velocity of movement of water in the saturated and unsaturated zones (DOE/NV 1992c). Depth to groundwater varies from about 660 feet (200 meters) beneath valleys in the southern part of the NTS to more than 1,640 feet (500 meters) beneath Pahute Mesa. The depth of the water table below Area 5 is approximately 800 feet (244 meters) below land surface (DOE/NV 1993c). Locally, there are perched water tables at shallow depths (USAF et al. 1991). Perched aquifers have been reported at depths of 70 feet (21 meters) in the southwestern part of Frenchman Flat (RSN 1993). In the eastern portions of the NTS, the water table occurs generally in the alluvium and volcanic rocks above the regional carbonate aquifer (DOE/NV 1993c).

The NTS lies within the Death Valley Groundwater System, which is a large and diverse area encompassing southern Nevada and adjacent parts of California composed of many mountain ranges and topographic basins that are hydraulically connected at depth. In general, groundwater within the system travels toward Death Valley, although much of it discharges before reaching it. Groundwater in the Death Valley system does not enter neighboring groundwater systems (DOE 1986). The Death Valley Groundwater System is divided into several groundwater subbasins. The boundaries of these subbasins have been estimated from potentiometric levels, geologic controls of subsurface flow, discharge areas, and inferred flow paths (DOE 1988b). As shown in Figure 4.8-2, the three groundwater subbasins of the system beneath the NTS are Ash Meadows, Alkali Flat Furnace Creek Ranch, and Oasis Valley. Groundwater beneath the eastern part of the NTS is in the Ash Meadows Subbasin. Most of the western NTS is in the Alkali Flat Furnace Creek Ranch Subbasin. Groundwater beneath the far northwestern corner of the NTS occurs in the Oasis Valley Subbasin (DOE/NV 1993c, 1992b).

Six major aquifers occur in the area. In decreasing order of age of the geologic units in which they are found, they are: Cambrian through Devonian lower carbonate aquifer, Pennsylvanian and Permian upper carbonate aquifer, Tertiary bedded tuff aquifer, Tertiary welded tuff aquifer, Tertiary lava flow aquifer, and Tertiary and Quaternary valley fill aquifer (Eckel 1968) (see Figure 4.6-2). The hydrologic and geologic properties of these aquifers vary (see the Yucca Mountain Site Characterization Plan [DOE 1988b] for a thorough description of the hydraulic properties of the major hydrostratigraphic units based on studies at Yucca Mountain). For example, the carbonate aquifers and the welded tuff aquifer store and transmit water chiefly along fractures. In contrast, the valley fill aquifer stores and transmits water chiefly through interstitial openings. Additionally, in places in the lower carbonate aquifer, groundwater flow is diverted laterally and vertically because of fault displacements that have juxtaposed the lower carbonate aquifer against less permeable rocks. Where the flow is blocked, intersection of the water table with the land surface causes springs (DOE 1986).

Figure 4.8-2. Groundwater hydrologic units, hydrgraphic areas, and well locations of the Nevada Test Site.

The lower carbonate and valley fill (alluvial) aquifers are the main sources of groundwater in the eastern part of the NTS (DOE 1986). Groundwater withdrawals in the area of the proposed SNF management facilities are principally from the valley fill aquifer of the Frenchman Flat hydrographic area (DOE 1988b). The other four units in the area have relatively low permeabilities that tend to retard the flow of groundwater. These units are called aquitards (DOE 1986). In decreasing order of age of the geologic units that form them, these aquitards are: Precambrian through lower Cambrian lower clastic aquitard, Devonian through Mississippian upper clastic aquitard, Tertiary tuff aquitard, and Tertiary lava flow aquitard (Eckel 1968) (see Figure 4.6-2).

Figure 4.8-3 is a regional groundwater potentiometric surface map of the NTS (DOE/NV 1993d). The map does not show perched groundwater. However, perched groundwater does occur at NTS, principally associated with the aquitards underlying the ridges (Eckel 1968).

In general, regional groundwater flow is from the north and northeast toward the regional discharge area near Ash Meadows in the Amargosa Desert (see Figure 4.8-2 and 4.8-3). In the western portions of the area, the regional flow is from the northwest to the south and southwest (DRI 1986b). Deep regional movement of groundwater south of the NTS occurs chiefly through the lower carbonate aquifer. Because of geologic structure, flow paths in the lower carbonate aquifer are complex and poorly defined. Groundwater from the Ash Meadow Subbasin supplies the water entering Devil's Hole, which supports the only known population of the Devil's Hole pupfish, a federally listed endangered species. The decline of the species has been attributed to low water levels caused by decreasing groundwater levels (ERDA 1977).

Groundwater recharge to the Ash Meadows Subbasin occurs primarily from precipitation over the mountainous areas in the northern, eastern, and southern portions of the basin (DOE 1988b). As mentioned above, this recharge generally travels vertically through the vadose zone (unsaturated zone) and the overlying aquifers to the underlying carbonate aquifers. Specifically, in the eastern half of the NTS, groundwater flows toward the major valleys before deflecting downward to join the regional flow in the carbonate aquifers. Beneath Yucca and Frenchman flats, vertical flow through the underlying volcanic rocks is impeded by bedded and zeolitized tuffs, resulting in a downward flow rate of less than 0.2 foot (0.06 meter) per year.

Figure 4.8-3. NTS regional potentiometric surface map.

Vertical flow in the uppermost portions of the vadose zone in the area of Frenchman Flat is generally upward toward the surface, due to an evapotranspiration rate which is 15 times higher than precipitation (DOE/OFE 1994). Site characterization data for Area 5 indicate that the vertical flow direction in the vadose zone is upward from 0 to 250 feet (0 to 75 meters) below land surface. In the next interval (250 to 600 feet [75 to 180 meters]), a downward flow rate of 10 feet/1,000 years (3 meters/1,000 years) has been calculated. At a depth of 600 to 800 feet (180 to 250 meters), a zone of equilibrium (a zone of no vertical movement) is present above the water table (Johnejack et al. 1994).

Analyses have also been conducted in order to determine the travel time of water from the vicinity of Area 5 and Frenchman Flat to the regional water table. Modeling studies for the Radioactive Waste Management Site at Area 5 indicate that the travel time from the surface to the water table is on the order of thousands of years (DOE/NV 1993c). Specifically, the travel time from Area 5 to the regional water table is estimated to range from 19,000 to more than 113,000 years (USAF et al. 1991). The Yucca Mountain Site Characterization Plan (DOE 1988b) describes in detail the hydraulic properties of the various units comprising the unsaturated zone, based on studies at Yucca Mountain.

Three types of groundwater chemistry exist at the NTS and in its vicinity: (1) sodium and potassium bicarbonate, which generally occurs in the tuff and valley fill aquifers composed chiefly of tuff detritus; (2) calcium and magnesium bicarbonate, which generally occurs in the carbonate and the valley fill aquifers composed chiefly of carbonate detritus; and (3) mixed, which is defined as having the chemical characteristics of both type 1 and type 2 (DOE 1986).

The hydrogeologic units which supply potable water to the NTS have been classified as

Class IIA (currently a source of drinking water) and IIB (potentially a source of drinking water) in accordance with the EPA's guidelines for groundwater classification (DOE/NV 1993d). No aquifers at the NTS have been designated as sole source aquifers.

In general, the quality of NTS groundwater is suitable for most purposes and generally meets EPA secondary standards for major cations and anions and the primary standards for deleterious constituents. Specifically, groundwater in the Ash Meadows Subbasin has a total dissolved solids concentration ranging between 275 and 450 milligrams per liter (mg/L) (DOE/NV 1993a). Summary groundwater quality data for the period 1957 to 1990 for Well 5b, 5c, Well UE5c, and Army Well 1 which serve Area 5 reveal a pH range of 7.6 to 8.7; calcium (2.4 to 44.0 mg/L); sodium (38.1 to 129.0 mg/L); chloride (9.1 to 23.2 mg/L); sulfate (26 to 58 mg/L); and silica (0 to 55.1 mg/L) (DRI 1993).

Contamination by radionuclides occurs below the water table as well as in the unsaturated zone above it. This contamination is a result of underground nuclear testing. A preliminary environmental survey of the NTS also identified a number of potential sources of groundwater contamination. These included wastewater discharges, hazardous- or mixed-waste discharges, solid waste landfills and trenches receiving potentially hazardous waste, and over 50 inactive waste spill or release sites (USAF et al. 1991).

Underground nuclear testing has primarily occurred in the areas of Yucca Flat, Frenchman Flat, Pahute Mesa, Rainier Mesa, and Shoshone Mountain. Nuclear detonations at or near the water table have resulted in groundwater contamination. The principal confirmed or suspected contaminants from these tests include various radionuclides (primarily tritium) and heavy metals. A number of NTS waste disposal and testing facilities, including injection wells, leach fields, and various waste storage facilities or disposal sites, have caused contamination of the vadose zone. Contaminants of concern include radionuclides, organic compounds, heavy metals (primarily lead), and hydrocarbons as well as various residues from plastics, drilling muds, and epoxy (DOE/NV 1993e). Figure 4.8-4 depicts the areas with known or suspected groundwater and/or vadose zone contamination. Groundwater contamination characterization activities are in progress at NTS; at present, no contaminant plume maps are available, and available groundwater quality data are not useful for the purposes of site-wide characterization or for comparison with established criteria.

Groundwater contamination could be transported toward the NTS boundary by one of the regional groundwater flow systems. Groundwater flow velocities in these systems range between 6 and 600 feet (1.8 and 183 meters) per year. Because of sorption, however, most nuclides (other than tritium) would move at a much slower rate. The groundwater travel time from the NTS to the Ash Meadows Discharge Area of the Ash Meadows Subbasin Flow System is approximately 300 years. Radioactive decay during this time, coupled with dilution and sorption, should reduce radioactivity concentrations to well below regulatory limits (USAF et al. 1991). Thus, there are no effects on public health and safety, nor are any expected in the foreseeable future.

Figure 4.8-4. Areas of potential groundwater contamination at the NTS.

The NTS derives its complete water supply from the groundwater aquifers underlying the site. Water supply has been developed and is managed on the basis of five service areas that support the different NTS operating areas. Given the wastewater disposal practices on the NTS and the depth to the groundwater system, it is reasonable to assume that all of the water pumped on the NTS is consumed (USAF et al. 1991). Recent annual water use at the NTS has declined substantially from the 1980's. In 1989, NTS annual water withdrawal was 1.117 billion gallons (4.22 million cubic meters) (Leppert 1993). In 1992, NTS annual water withdrawal was 0.595 billion gallons (2.25 million cubic meters) (Leppert 1993).

In 1993, 14 wells were utilized for the NTS water supply (DOE/NV 1994c). A small portion of the NTS receives its water from 5 onsite wells drilled in the Alkali Flat-Furnace Creek Ranch Subbasin (DOE 1988b). Most of the NTS receives its water from 9 onsite wells drilled in the Ash Meadows Subbasin, which encompasses Area 5 (DOE/NV 1994c). These 9 wells have a combined production capacity of 1,813 billion gallons per year (6.86 million cubic meters per year) (DOE/NV 1993a).

Area 5, which encompasses the proposed SNF facility site, is located within NTS water service area C. Wells 5b, 5c, and UE5c serve the fire protection, construction, and potable water needs of Area 5 facilities (DOE/NV 1993b). Wells 5b and 5c are completed in alluvial materials (valley fill aquifer) with total completion depths of 900 and 1,200 feet (274 and 366 meters) below land surface, respectively. Well UE5c is completed in volcanic rock (exact aquifer unknown) with a total depth of 2,682 feet (817 meters) below land surface (DOE 1988b; DOE/NV 1993b; DRI 1993).

Groundwater for construction and operation of the SNF management facilities would likely be drawn from the Frenchman Flat hydrographic area of the Ash Meadows Subbasin. Much of the land within the Ash Meadows Subbasin is under Federal jurisdiction and has been withdrawn from the public domain (DOE 1988b). Little of the total groundwater of the subbasin is privately appropriated or used.

The perennial yield of the Ash Meadows Subbasin greatly exceeds water withdrawals by DOE and all other users. For more than thirty years water withdrawals from the Frenchman Flat hydrographic area had exceeded the estimated precipitation recharge for that area (DOE 1988b). This study also indicates that withdrawals have caused no decline in the static water level (DOE 1988b). However, it should be noted that numerous conditions on the NTS preclude the accurate measurement of static water levels (Winograd 1970). Because of hydrogeologic complexities, regional groundwater flow at the NTS is not constrained by the hydrographic basins which are defined by local topography (USAF et al. 1991). Therefore any potential groundwater overdrafts in the Frenchman Flat basin indicated by previous yield estimates are likely made up by untapped groundwater from neighboring hydrographic basins.

Water in southern Nevada (excluding the Las Vegas area) is used chiefly for irrigation and to a lesser extent for livestock, municipal needs, and domestic supplies. Almost all the required water is pumped from the ground, although some springs supply water to establishments in Death Valley and other areas south of the NTS. Springs in Oasis Valley near Beatty, Nevada are a significant source of water for public and domestic needs and for irrigation (DOE 1986). The City of Las Vegas obtains approximately 80 percent of its water from the Colorado River; the remaining 20 percent is withdrawn from groundwater sources. There are no plans to change the water supply sources in the near future. (Las Vegas Valley Water District 1994).

The principal water users in the area closest to the NTS are in the Amargosa Desert in and around the Town of Amargosa Valley and in the Pahrump Valley. Aquifers in the Pahrump Valley could support up to about 16,900 residents with no decline in usable storage, although local effects, such as land subsidence and well interference, could result from sustained development. The mining industry in southern Nevada also uses a small amount of water for processing. Water for this purpose is supplied from nearby shallow wells or trucked in from nearby towns. Many of the mines currently recycle process water, which reduces their water demand (DOE 1986).

The volume of groundwater underlying the NTS (as well as the estimated volume of contaminated groundwater) that has been removed from direct access to the general public is rather large. The impaired groundwater will likely remain unusable for an extended period. The significance of the loss of access to the NTS groundwater is diminished by the fact that even if access were provided, the water underlying portions of the NTS might not be usable for domestic purposes (USAF et al. 1991).

4.9 Ecological Resources

NTS lies within the transition area between the Mojave Desert and the Great Basin. As a result, flora and fauna characteristics of both occur on the NTS. The NTS covers about 3,500 square kilometers (1,350 square miles) of which only 0.55 percent is developed (DOE/NV 1988).

NTS has completed numerous studies on the effects of nuclear testing on the ecology of the area, and an extensive bibliography of these studies has been prepared (ERDA 1976). In summary, studies (including ongoing surveys) have shown that there may be a correlation between radioactive testing and the decline of vegetation present in an area. As a result, animals may not have the necessary vegetation for food and cover, thus changing the fauna diversity in those areas (USAF et al. 1991).

The following section describes the ecological resources at the NTS, including terrestrial resources, wetlands, aquatic ecology, and threatened and endangered species. Information is also presented on special status species other than threatened and endangered species such as Federal Candidate and state-listed species.

4.9.1 Terrestrial Resources

Plant communities on the NTS have been classified according to the dominant shrub. Approximately 700 taxa, representing about 70 families, have been identified on the NTS (ERDA 1976; DOE/NV 1993b, 1991b). Figure 4.9-1 presents the general plant communities identified there.

Figure 4.9-1. Plant communites on Nevada Test Site.

The Mojave Desert is located at elevations ranging up to 1,219 and 1,524 meters (4,000 and 5,000 feet). The dominant plant community is creosote bush (Larrea tridentata). Areas in which this community occurs are located within much of the southern portion of the NTS, including Jackass Flats and Frenchman Flat (DOE/NV 1991b, 1986b; ERDA 1976; FWS 1992).

The transitional zone between the Mojave Desert and the Great Basin occurs at elevations between 1,219 and 1,524 meters (4,000 and 5,000 feet). The dominant plant communities associated with the transition zone are: blackbrush (Coleogyne ramosissma), desert thorn (Lycium pallidum), and hopsage (Grayia spinosa). In general, these communities are found in upper bajadas and in closed basins within Jackass Flats and Yucca Flat (DOE/NV 1991b, 1986b; ERDA 1976).

The Great Basin is located within the northern two-thirds of NTS at elevations above 1,524 meters (5,000 feet). The dominant plant communities are big sagebrush (Artemisia tridentata) and black sagebrush (Artemisia nova), saltbush (Atriplex canescens), and desert thorn (Lycium shockleyi). In areas with elevations above 1,830 meters (6,000 feet), collectively labeled as mountains, hills, and mesas, the dominant plant communities are singleleaf pinyon (Pinus monophylla) and Utah juniper (Juniperus osteosperma). In general, these communities are found at Thirsty Canyon, Yucca Playa, Rainier Mesa, and Yucca Mountain (DOE/NV 1991b, 1986b; ERDA 1976).

There is a recent trend of nonnative plant species establishing themselves in areas of disturbance at the NTS. Cheatgrass (Bromus tectorum), an annual grass, occurs at elevations above 1,524 meters (5,000 feet). Downey chess (Bromus rubens), another annual grass, is becoming established in the mid-elevations. Russian thistle (Salsola iberica and S. paulsennii) appears in areas where the native vegetation has been removed and the soil composition has changed (DOE/NV 1991b, 1988; ERDA 1976).

Like vegetation, animals on the NTS are representative of both the Mojave Desert and the Great Basin and the associated transition zone. There are over 30 species of reptiles and amphibians, 190 species of birds, and 50 species of mammals on the NTS (DOE/NV 1993b; ERDA 1976). Many animals utilize man-made reservoirs and natural springs and seeps on the NTS. Sewage ponds have also become an important resource for wildlife.

Reptiles and amphibians on the NTS include 1 species of desert tortoise, 14 species of lizards, and 17 species of snakes. In addition, the NTS is within the range of the Great Basin spadefoot toad (Scaphiopus intermontanus), but this amphibian has not been identified on the NTS (DOE/NV 1993b; ERDA 1976; Medica 1990).

Birds on the NTS are often migratory and seasonal residents. The most widely distributed species include the black-throated sparrow (Amphispiza bilineata), house finch (Carpodacus mexicanus), red-tailed hawk (Buteo jamaicensis), common raven (Corvus corax), loggerhead shrike (Lanius ludovicianus), mockingbird (Mimus polyglottos), ash-throated flycatcher (Myiarchus cinerascens), and mourning dove (Zenaida macroura) (DOE/NV 1993b; ERDA 1976; Greger 1991).

The most abundant group of mammals on the NTS are rodents. Carnivores include coyote (Canis latrans), kit fox (Vulpes macrotis), badger (Taxidea taxus), bobcat (Lynx rufus), mountain lion (Felis concolor), and long-tailed weasel (Mustella frenata). Large mammals on NTS include the mule deer (Odocoileus hemionus), pronghorn (Antilocapra americana), desert big horn sheep (Ovis canadensis), and wild horse (Equus caballus). Hunting, grazing, and fishing are not allowed on the NTS (DOE/NV 1993b, 1986b; ERDA 1976; Medica and Saethre 1990).

In general, the portion of Frenchman Flat in Area 5 (i.e., north and east of Mercury Highway) within which the proposed SNF facility would be located is within the creosote bush community. This plant community is characteristic of the Mojave Desert. Pre-activity surveys completed for the Radioactive Waste Management Site, which is in the general area of the proposed SNF facility, found the dominant vegetation to include creosote bush, spiny hopsage, white bursage, desert thorn, and Nevada joint-fir (Ephreda nevadensis) (EG&G 1993, 1991, 1990, 1989).

The distribution of animals within the portion of Area 5 being considered for the proposed SNF facility is not as well documented as for the rest of the NTS. However, species identified within 5 kilometers (3.1 miles) of the Liquefied Gaseous Fuels Spill Test Facility include 8 reptiles, 17 bird species, and 14 mammals (Hunter et al. 1991). The Liquified Gaseous Fuels Spill Test Facility is located within similar habitat approximately 7.6 kilometers (5 miles) south of the proposed facility. There are no water sources located within the portion of Area 5 being considered for the proposed SNF facility.

4.9.2 Wetlands

There are several natural springs on the NTS that feed flowing streams (Greger and Romney nda). Some of these extend for 91 meters (300 feet) before infiltration and evaporation cause them to dry up. Vegetation along these channels consists of willow (Salix sp.) and tamarisk (Tamarix sp.). Reservoirs on the site which are fed by groundwater from wells have developed wetland vegetation such as tamarisk, cattail (Typha sp.), and bulrushes (Scirpus sp.) (Elle 1992). A wetland delineation, as defined by the 1987 U.S. Army Corps of Engineers wetlands Delineation Manual (U.S. COE 1987), has not been performed for any of these areas (DOE/NV 1993b; Elle 1992), and National Wetlands Inventory maps are not available for the NTS.

The portion of Area 5 under consideration for the SNF facility does not have any known springs, seeps, or wetland vegetation (DOE/NV 1993b; Greger and Romney nda).

4.9.3 Aquatic Resources

Potential aquatic habitat on the NTS includes surface drainages, playas, man-made reservoirs, and springs. Permanent surface water sources are limited to a few small springs.

There are two dry lake beds (playas) located in the eastern (Yucca Flat) and southeastern (Frenchman Flat) portions of the NTS. Runoff from the eastern half of the NTS flows through surface drainages to onsite playas and can collect for a few days to a few months. The remaining areas of the NTS drain offsite via arroyos and dry stream beds that carry water only during intense or persistent rainstorms. These surface drainages and playas are unable to support permanent fish populations (ERDA 1976; Greger and Romney nda).

Reservoirs resulting from discharge of well water located on the NTS support three introduced species of fish: bluegill (Lepomis macrochirus), goldfish (Carassius auratus), and golden shiner (Notemigonus crysoleucas). Springs located throughout the site do not support fish populations (Elle 1992). There are no springs, seeps, or other permanent water bodies on the proposed SNF Site; however Cane Spring is located in Area 5, southwest of the proposed SNF Site (Greger and Romney nda).

4.9.4 Threatened and Endangered Species

Table 4.9-1 presents a list of federally and state-listed species that may be found in the vicinity of NTS.

There are no known plants which have been listed as threatened or endangered under the

Endangered Species Act (16 USC 1531-1534) on NTS. However, the U.S. Fish and Wildlife Service has identified candidate species for listing, 11 of which may occur on or in the vicinity of the NTS. Ten of these are Candidate Category 2 species, meaning that information indicates that they may be appropriate for listing as endangered or threatened but more information is needed. One species, the Beatley milk-vetch, is a Candidate Category 1 species (DOE/NV 1993b, 1991c; EG&G 1993; USAF et al. 1991). This species has been identified on Pahute Mesa (Hunter et al. 1988). A Candidate Category 1 species is one for which there is substantial information indicating that it is appropriate for listing as endangered or threatened Four Candidate Category 2 species (camissona, black wooly-pod, cymopterus, and Beatley phacelia) have been identified in Frenchman Flat, although none of these was identified during surveys conducted near the proposed SNF facility site (EG&G 1993; Tetratech 1993).

Two listed reptile species on or in the vicinity of NTS are of concern. The chuckwalla is a Federal Candidate Category 2 species which may occur on NTS. The desert tortoise is the only federally listed threatened species known to occur on NTS (DOE/NV 1993b; EG&G 1993). Both the desert tortoise and the chuckwalla are listed as reptile species of Frenchman Flat (DOE/NV 1986b).

Table 4.9-1. Federally and state-listed threatened, endangered, and other special status species that may be found in the vicinity of the Nevada Test Site.

		Statusb	
Common name	Scientific name	Fed.	State
	Plants		
Amargosa penstemon	Penstemon fruticiformis ssp. amargosae	C2	NL
Beardtonguec	Penstemon pahutensis	C2	NL
Beatley milkvetchc	Astragalus beatleyae	C1	CE
Beatley phaceliac	Phacelia beatleyae	C2	NL
Black wooly-podc	Astragalus funerus	C2	NL
Camissoniac	Camissonia megalantha	C2	NL
Cymopterusc	Cymopterus ripleyi var. saniculoides	C2	NL
Green-gentianc	Frasera pahutensis	C2	NL
Kingston bedstrawc	Galium hilendiae ssp. kingstonense	C2	NL
Mojave fishook cactusc	Sclerocactus polyancistrus	NL	CY
White bear desert-poppyc	Arctomecon merriamii	C2	NL
	Birds		
Bald eagled	Haliaeetus leucoephalus	E	E
Golden eaglec	Aquila chrysaetos	NL	P
Ferruginous hawkc	Buteo regalis	C2	NL
Loggerhead shrikec	Lanius ludovicianus	C2	NL
Mountain ploverc	Charadrius montanus	C2	NL
Peregrine falcond,e	Falco peregrinus	E	E
Western least bittern	Ixobrychus exilis hesperis	C2	NL
Western snowy ploverc	Charadrius alexandrinus nivosus	C2	NL
White-faced ibisc	Plegadis chihi	C2	NL
	Reptiles		
Chuckwalla	Sauromalus obesus	C2	NL
Desert tortoisec	Gopherus agassizit	T	T
	Mammals		
Spotted bat	Euderma maculatum	C2	NL
Pygmy rabbit	Branchylqus idahoensis	C2	NL
	Fish		
Devils Hole pupfishd,f	Cyprinodon diabolis	E	E

a. Sources: CFR (1993c,d); ERDA (1976); EG&G (1993); DOE/NV (1986b); FR (1991, 1990b); FWS (1993); Hunter et al. (1988); NV DCNR (1992); Tetratech (1993).

b. Status codes:
C1 Federal candidate - Category 1 (probably appropriate to list)
C2 Federal candidate - Category 2 (possibly appropriate to list more study required)
CE State critically endangered by authority of NRS 527.270 (State Division of Forestry)
CY State protected by authority of NRS 527.60-.120 under the Nevada Cacti and Yucca Law
E Endangered
NL Not listed
T Threatened
P State protected by NAC 503.050

c. Species recorded on the NTS.

d. U.S. Fish and Wildlife Service Recovery Plan exists for this species.

e. Peregrine falcon seen on the NTS; however not identified to subspecies level.

f. Only known location of this species is outside the NTS 24 miles (39 km) southwest of Mercury. This species is included here due to potential offsite groundwater impacts.

Note: Nevada Department of Wildlife utilizes the Federal threatened and endangered species list.

The distribution and abundance of the desert tortoise have been extensively researched; the latest research for the NTS as a whole was completed in 1991 (DOE/NV 1991c). A biological opinion from the U.S. Fish and Wildlife Service was completed in 1992 for NTS activities planned for 1992 through 1995 (FWS 1992). The desert tortoise is known to exist in the southern portion of the NTS, but its abundance on the NTS is considered to be very low to low (DOE/NV 1991c). The northern extent of its range is from Massachusetts Mountain through Control Point Hills and Mid Valley to Topopah Valley and west to the NTS boundary (DOE/NV 1991c).

Two bird species which could occur on or within the vicinity of NTS are federally listed endangered species. These are the American peregrine falcon and the bald eagle. The American peregrine falcon has been sighted on the NTS in the past but not recently (DOE/NV 1991c; ERDA 1976). Bald eagles may also occur on the NTS, but sightings have not been reported in recent literature (DOE/NV 1986b; EG&G 1993; ERDA 1976; Hunter et al. 1991). Six other bird species, all of which are Federal Candidate Category 2 species, are known to occur on or within the vicinity of NTS (DOE/NV 1991c; EG&G 1993). Recent surveys of Area 5 (which contains the proposed SNF Site) have not identified any of these species (DOE/NV 1986b; EG&G 1993, 1991, 1990, 1989). However, birds listed as common to Frenchman Flat include the golden eagle and loggerhead shrike (DOE/NV 1986b; Tetratech 1993).

There are two Federal Candidate Category 2 mammal species identified as potentially occurring in the vicinity of the NTS. Neither the spotted bat nor the pygmy rabbit has been observed during recent pre-activity surveys for the area (EG&G 1993; USAF 1993). They are also not listed as mammals occurring in Frenchman Flat (DOE/NV 1986b; Tetratech 1993).

There are no known fish species indigenous to the NTS. However, it is important to note that the only known location of the Devils Hole pupfish, a federally listed endangered species, is approximately 39 kilometers (24 miles) southwest of the NTS. The decline of this species has been attributed to low water levels caused by decreasing groundwater levels (ERDA 1977; USAF et al. 1991).

Pre-activity surveys for threatened and endangered species have recently been completed for the Radioactive Waste Management Site located in Area 5 near the proposed SNF facility. The primary purpose of these surveys was to identify live tortoise, scat, burrows, and remains. Although these surveys have found few tortoise or their sign, each new activity on NTS must undergo pre-activity surveys for the desert tortoise (DOE/NV 1991c; EG&G 1993, 1991). In addition, these surveys look for other listed species. Recent surveys have not identified any other listed or candidate species in the portion of Area 5 surrounding the Radioactive Waste Management Site, which is near the proposed SNF Site (EG&G 1993, 1991).

4.10 Noise

The major noise sources at the NTS occur primarily in developed operational areas and include various facilities, equipment and machines (e.g., cooling towers, transformers, engines, pumps, boilers, steam vents, paging systems, construction and materials-handling equipment, and vehicles), aircraft operations, and testing. No NTS environmental noise survey data are available.
At the NTS boundary, away from most facilities, noise from most sources is barely distinguishable from background noise levels. Some disturbance of wildlife activities might occur within the NTS as a result of operational activities and construction activities.

Existing NTS-related noise sources of importance to the public are those from transportation of people and materials to and from the NTS. These sources include trucks, buses, private vehicles, helicopters, and airplanes. In addition, some air cargo and business travel via commercial air transport through the McCarren International Airport in Las Vegas can be attributed to the NTS operations.

The State of Nevada and Nye County have not established any regulations that specify acceptable community noise levels with the exception of prohibitions on nuisance noise.

During a normal week, about 3,300 employees travel to the NTS each day. Most employees commute using the contracted bus service and a small portion commute in government or private vehicles. Both government-owned and private trucks pick up and deliver materials at the site. Most of the private vehicles, buses, and trucks travel to and from the site each day using U.S. Route 95. The contribution of the NTS operations to traffic volumes along U.S. Route 95, especially during peak traffic periods, affects noise levels at residences along this route.

4.11 Traffic and Transportation

Traffic congestion is measured by level of service. Level of Service A represents free flow of traffic. Level of Service B is in the range of stable flow, but the presence of other users in the traffic stream begins to be noticeable. Level of Service C is in the range of stable flow, but marks the beginning of the range of flow in which the operation of individual users becomes significantly affected by interactions with others in the traffic stream. Level of Service D represents high-density but stable flow. Level of Service E represents operating conditions at or near the capacity level. Level of Service F is used to define forced or breakdown of flow of traffic. The calculated Level of Service are for discrete locations along a segment. Level of Service will most likely be worse in urban areas and better in rural areas along with the segment.

The Region of Influence for the following analysis includes site roads and regional roads in Nye and Clark counties.

Vehicular access to the NTS is provided by U.S. Route 95 to the south, with off-road access to the northeast provided via Nevada State Route 375. Baseline traffic along segments providing access to the NTS contributes to differing service level conditions. Nevada State Route 375 and U.S. Route 95 are projected to remain at Level of Service A. No major improvements are presently scheduled for those segments providing immediate access to the NTS (NDOT 1992). Regional roads and local roads providing access to NTS are presented in Figures 2.1-1 and 2.1-2, respectively.

Future background traffic (defined as all future traffic not attributable to the proposed SNF facilities) is projected to contribute to differing service-level conditions for local roads in 2001.
The year 2001 was selected for analysis because that is when the impacts from the proposed SNF facilities would be highest. All local and regional roads are projected to operate at Level of Service A.

The Level of Service was calculated using average daily traffic counts (NDOT 1992) and standard parameters (ITE 1991; Rand McNally 1993; TRB 1985).

The public transit serves the heavily populated regions of Clark County. Contract buses run to the NTS. There is no public transportation system serving the NTS; however, approximately 70 buses a day transport employees to and from the site. The nearest major railroad is the Union Pacific, located approximately 50 miles (80 kilometers) east of the NTS. A 9-mile (15-kilometer) standard-gauge railroad serves Area 25 of the NTS but does not connect with the Union Pacific (ERDA 1977). No navigable waterways within the Region of Influence are capable of accommodating waterborne transportation of material shipments to the NTS.

McCarran International Airport in Las Vegas provides jet air passenger and cargo service from both national and local carriers. It is outside the Region of Influence. Smaller private airports are located throughout the Region of Influence. Desert Rock Airstrip, the onsite airport, is located near Mercury.

4.12 Occupational and Public Health and Safety

Health impacts to the public from activities on the NTS are minimal as a result of administrative and design controls to minimize releases of pollutants to the environment and to achieve compliance with permit requirements, e.g., air emissions and National Pollutant Discharge Elimination System permit requirements. The effectiveness of these controls is verified through the use of monitoring and inspections. Health impacts to the public may occur during normal operations at the NTS via inhalation of air containing radioactive and chemical pollutants released to the atmosphere, immersion in this air, and ingestion of food contaminated by these pollutants. Risks to public health from other possible pathways such as exposure to contaminated soil are low relative to these pathways.

Health impacts to NTS workers during normal operations may include those from inhalation of the workplace atmosphere, consumption of potable water, direct exposure, and possible other contact with hazardous materials associated with work assignments. The potential for health impacts varies from facility to facility and from worker to worker, and available information is not
sufficient to allow a meaningful estimation and summation of these impacts. However, workers are protected from hazards specific to the workplace through appropriate training, protective equipment, monitoring, and management controls. NTS workers are also protected by occupational standards that limit atmospheric and drinking water concentrations of potentially hazardous chemicals and that also limit radiation exposure. Monitoring ensures that these standards are not exceeded. Additionally, DOE requirements (DOE Order 3790.1B) ensure that conditions in the workplace are as free as possible from recognized hazards that cause or are likely to cause illness or physical harm. Therefore, worker health conditions at the NTS are expected to be substantially better than required by standards.

Health effects from radiation are presented here as the risk of fatal cancer. This risk is in
the ratio of the health risk estimator (risk of fatal cancer per rem of exposure). The value of this
estimator for exposures to the public is 5.0 x 10-4 for fatal cancers. The corresponding estimator
for exposures to workers is 4.0 x 10-4.

The DOE Nevada Field Office published a Waste Minimization and Pollution Prevention Awareness Plan in June 1991 to reduce the quantity and toxicity of hazardous, mixed, and radioactive wastes generated at DOE/NV facilities. The plan is designed to reduce the possible pollutant releases to the environment and thus increase the protection of employees and the public. All DOE/NV contractors and NTS users that exceed the EPA criteria for small-quantity generators are establishing their own waste minimization and pollution prevention awareness programs that are implemented by the DOE/NV plan. Contractor programs ensure that waste minimization activities are in accordance with Federal, state, and local environmental laws and regulations, and DOE Orders (DOE/NV 1993c).

Additional goals include the promotion and use of nonhazardous materials, establishment of a baseline of waste generation data, calculations of annual reductions of wastes generated, and implementation of recycling programs. Goals also include incorporation of waste minimization concepts and technologies in planning and design of new processes and facilities, and in upgrades of existing facilities. A waste minimization task force composed of representatives from each contractor and NTS user has been established to coordinate DOE/NV waste minimization and pollution awareness activities (DOE/NV 1993c).

4.12.1 Doses

4.12.1.1 Radiological Doses. Every individual is affected by natural and other

background radiation. The major sources of background radiation exposure to individuals in the vicinity of the NTS are shown in Figure 4.7-2. All annual doses to individuals from background radiation are expected to remain constant over time.

Releases of radionuclides to the environment from NTS operations provide another source of radiation exposure to people in the vicinity of the NTS. Table 4.7-2 summarizes the airborne radionuclides and quantities released in curies during baseline NTS operations. The annual committed doses to the public resulting from these release are given in Table 4.7-4. Compared to those from natural background radiation, these doses are very small. The doses are all less than 1 percent of the most restrictive standard given in DOE Order 5400.5.

Workers at the NTS receive the same dose as the general population from background radiation but also receive an additional dose from working in the facilities. The doses to the average and maximally exposed workers due to operation in 1991 (assumed representative of 1995 operations), were approximately 5 and 500 millirem, respectively; the total dose to all workers was about 4 person-rem (DOE/NV 1992c). The maximum dose is well within the limit of 5,000 millirem per year specified in DOE Order 5480.11 and in 10 CFR 835.

4.12.1.2 Nonradiological Doses. Every individual is also affected by background

concentration of nonradiological pollutants. The maximum background concentrations for those criteria pollutants which have been measured is provided in Table 4.7-5. The maximum existing DOE site contribution concentration was then computed, as discussed in Section 4.7.

4.12.2 Health Effects

4.12.2.1 Radiological. The fatal cancer risk to the maximally exposed member of the

public due to the radiological emissions from NTS baseline operations in 1995 would be 5.5 x 10-9. The same risk estimator projects 2.6 x 10-6 excess fatal cancer to the population within 80 kilometers (50 miles) of the NTS. These values would be approximately 2.2 x 10-7 and 1 x 10-4, respectively, during the 40 years of SNF facility operations.

Because of the different age distribution of a working population, the health risk estimators for workers are somewhat lower than for members of the general public. As a result of 1995 baseline operations at the NTS, these estimators predict a fatal cancer risk of 2.0 x 10-4 to the maximally exposed worker, and 1.6 x 10-3 excess fatal cancer among all workers. The risk faced by an average worker would be 2.0 x 10-6. Over the 40-year operating life of the proposed SNF facility, and assuming a particular worker during this time, these values would be 8.0 x 10-3, 6.4 x 10-2, and 8.0 x 10-5, respectively.

4.12.2.2 Nonradiological. As discussed in Section 4.7, the maximum existing DOE site

contribution of criteria nonradiological air pollutants were computed. In Table 4.7-5 the total existing maximum concentration (which adds the maximum existing DOE site contribution to the maximum background concentration) is presented. The total existing maximum concentration values represent the highest concentrations to which members of the public would be exposed. In every case where information was available, the highest concentration was less than the applicable health-based standard.

4.12.2.3 Health Effects Studies. The epidemiologic studies concerning the NTS have

concentrated on the health effects in soldiers and children associated with nuclear testing rather than on plant emissions (Beck and Krey 1983; Bross and Bross 1987; Caldwell et al. 1980; Lyon et al. 1979; Rallison et al. 1990; and others). The results regarding the observed leukemia incidence and deaths in exposed children are contradictory, with some studies reporting an excess and others reporting no excess. The validity of the analytical methods used in some of these studies are subject to various opinions. For soldiers, the results regarding leukemia and polycythemia vera differed between two studies relating to nuclear test explosions, but reanalyses showed leukemia, respiratory, and other cancers to be associated only with exposure to higher doses, e.g., more than 300 millirem for leukemia cases.

In March 1990, the Secretary of Energy announced that DOE would turn over responsibility for analytical epidemiologic research on long-term health effects on workers at DOE facilities and surrounding communities to the Department of Health and Human Services and directed that worker health and exposure data be released. A Memorandum of Agreement with the Department of Health and Human Services was signed in January 1991. The Department of Health and Human Services is now conducting the ongoing health effects research program. To develop a data base on workers, DOE has initiated an Epidemiologic Surveillance Program and a Health-Related Records Inventory.

4.13 Utilities and Energy

4.13.1 Water Consumption

There are 14 active wells which supply water to the NTS. Figure 4.8-2 in Section 4.8 shows the location of these wells. These 14 wells combined had a capacity of 387 liters per second (6,139 gallons per minute) in 1993 (DOE/NV 1993a). From 1988 to 1993, water use at the NTS varied from a high of 134 liters per second (2,125 gallons per minute) in 1989 to a low of 60 liters per second (949 gallons per minute) in 1993 (DOE/NV 1994c; Leppert 1993). Water usage projections to 1995 are unavailable; however, significant changes in the water consumption level are not anticipated.

There are also a number of deactivated wells located on the NTS. These wells could add additional water supply capacity if they were reactivated (Leppert 1993). It has been estimated that the activation of these wells could increase the available water supply by 85 liters per second (1,342 gallons per minute). Other methods to increase production of water could include increasing pump sizes or installing new wells (DOE/NV 1993a).

The proposed SNF site would be located in Area 5. There are four wells located in Area 5, two of which supply potable water. These two wells have a capacity of 38 liters per second (595 gallons per minute) (DOE/NV 1994c; 1993b). A third well in the area is currently being used to supply water for construction activities. The fourth well has been deactivated (DOE/NV 1993b). In 1993, Area 5 used approximately 12 liters per second (191 gallons per minute) of water, including the well used for construction purposes. Water usage for Area 5 is not expected to change substantially from 1993 to 1995 (DOE/NV 1994c; Leppert 1994).

4.13.2 Electrical Consumption

The NTS obtains electrical power from the Nevada Power Company and Valley Electric Association. Each company provides an independent 138 kilovolt transmission line to the site. The capacity of these transmission lines, with scheduled upgrades, is approximately 40 to 45 megavolt-amperes. The local utilities' 138 kilovolt transmission grids have adequate capacity within a 80-kilometer (50-mile) radius of the NTS to serve an additional 75 megavolt-amperes of load. In addition, the local utilities' proposed expansion of their existing 230 kilovolt transmission systems would make capacity in excess of 200 megavolt-amperes available within an 80-kilometer (50-mile) radius (DOE/NV 1993a).

From 1989 to 1993, the annual consumption of electricity ranged from a high of 183,118 megawatt hours in 1989 to a low of 144,521.5 megawatt hours in 1993. The peak demand varied from a high of 38.4 megavolt-amperes in 1989 to a low of 30.9 megavolt-amperes in 1993 (Leppert 1993; Thornton 1994). In 1995, the annual consumption of electricity is projected to be 176,440 megawatt hours, with a peak demand of 39.5 megavolt-amperes. The institution of energy management practices can regulate the peak demands of various NTS activities so that the maximum peak capacity is not exceeded. The predicted increase in overall electricity usage for 1995 is attributable to the increased requirements for the Yucca Mountain Site Characterization Project; the usage for the rest of the NTS is predicted to continue its downward trend (Thornton 1994).

The Frenchman Flat Substation, located in Area 5, has a capacity of 12.5 megavolt-amperes (Thornton 1994). A 34.5 kilovolt line from this substation feeds the loads at Area 6, Well C, the Tweezer facility, and the east side of the test areas used by LANL (DOE/NV 1993b). In 1993, the peak demand on the substation was 5.2 megavolt-amperes. This demand is not anticipated to change substantially from 1993 to 1995 (Thorton 1994).

4.13.3 Fuel Consumption

The majority of the energy used at the NTS is provided by electricity, but diesel fuel and fuel oil are used to provide heat in some facilities and backup power.

4.13.4 Wastewater Disposal

Currently, there are no wastewater disposal facilities in Area 5. Septic systems are used in parts of the NTS for sanitary wastewater disposal. These septic systems discharge to percolation/evaporation stabilization ponds. These ponds, however, are only used for the disposal of wastewater not generated by any manufacturing processes.

4.14 Materials and Waste Management

The operations conducted at the NTS have resulted in generation of low-level radioactive waste, hazardous waste, mixed waste (radioactive and hazardous combined), and sanitary waste (nonhazardous, nonradioactive solid waste). In addition, the NTS stores mixed transuranic waste received from Lawrence Livermore National Laboratory. This section discusses the treatment, storage, and disposal of waste at the NTS.

DOE currently operates two disposal facilities in Areas 3 and 5 at the NTS for low-level radioactive waste generated by DOE defense facilities. The Area 5 Radioactive Waste Management Site also serves as a interim storage area for LLNL transuranic wastes which will be shipped to the Waste Isolation Pilot Plant in New Mexico for final disposal. The Area 5 facility also accepts mixed waste, which contains both low-level radioactive waste and hazardous waste only if the waste was generated on the NTS.

All hazardous wastes generated at the NTS are disposed of offsite at commercial facilities approved and permitted by the EPA. Hazardous wastes are temporarily stored at the NTS in full compliance with Federal, state, and local requirements.

Mixed waste disposal facilities are presently operating under interim status, pending completion of the Resource Conservation and Recovery Act (RCRA) permitting process. Operation of the low-level radioactive waste and mixed waste disposal sites and the temporary transuranic waste storage site are supported by an environmental monitoring program that indicates waste is being safely contained in the near-surface environment in which it is emplaced.

The radioactive and mixed-waste disposal facilities are mainly shallow land burial areas. Figure 4.14-1 shows the location of the waste management facilities at the NTS (DOE/NV 1993b, 1992b).

The DOE Nevada Operations Office developed and implemented a Waste Minimization and Pollution Prevention Awareness Plan to reduce the quantity and toxicity of hazardous, mixed, and radioactive wastes generated at the NTS. The plan is designed to reduce the possible pollutant releases to the environment. The objectives of the waste minimization and pollution program are to:

- Identify processes generating waste streams
- Characterize and track each waste stream
- Identify, evaluate, and implement applicable waste minimization technologies
- Set numerical goals and schedules after the initial assessment of technological and economic feasibility
- Establish an employee pollution prevention awareness and training program.

Additional goals include the promotion and use of nonhazardous materials, establishment of a baseline of waste generation data, calculations of annual reductions of wastes generated, implementation of recycling programs, and incorporation of waste minimization concepts and technologies in planning and design of new processes and facilities and in upgrades of existing facilities.

The NTS manages the following waste categories: mixed transuranic waste, mixed low-level waste, low-level waste, hazardous waste, sanitary waste, and nonhazardous waste. The NTS does not currently manage high-level waste or SNF. The NTS waste management activities include onsite treatment, onsite storage, onsite disposal, and preparation for appropriate offsite disposal.

Additionally, the NTS uses and manages an onsite inventory of hazardous materials, including
Figure 4.14-1. Existing treatment, storage, and disposal units at the NTS. some managed in underground storage tanks. Figures 4.14-2 and 4.14-3 present flow diagrams of onsite generated waste management and waste shipment, receipt, and disposal, respectively.

Waste generation rates presented for each of the waste categories for the NTS represent 1993 waste generation rates unless otherwise stated and are assumed representative of the 1995 baseline year. Table 4.14-1 presents the baseline waste management for 1995 for those waste categories currently managed at the NTS. In addition, the table presents available disposal/ storage capacity and waste disposition.

4.14.1 Transuranic Waste

Transuranic waste from the Rocky Flats Plant and mixed-transuranic waste from LLNL are stored at the NTS at the transuranic waste storage cell located in Area 5 Radioactive Waste

Management Site. The transuranic waste has been characterized and repackaged, and the mixed-transuranic waste has been placed in a RCRA-permitted storage area consisting of 55-gallon drums and steel boxes stored on wooden pallets fixed upon a curbed asphalt pad. Approximately 204,663 kilograms (451,201 pounds) with a total volume of 612 cubic meters (800 cubic yards) of transuranic waste are stored at the NTS (DOE/NV 1994d). The NTS expects no additional transuranic or mixed-transuranic wastes to be stored at this unit.

4.14.2 Mixed Low-Level Wastes

The Area 5 Radioactive Waste Management Site contains Pit 3, which is an active mixed low-level waste management unit. Pit 3 is the only active landfill cell within the Area 5 Radioactive Waste Management Site for which a RCRA permit is being sought. Pit 3 is an unlined, trapezoidal shaped pit occupying 3.42 x 104 square meters (8.46 acres) with a process capacity of 1.29 x 105 cubic meters (1.69 x 105 cubic yards). The estimated disposal space for mixed low-level waste remaining at this facility is 9.03 x 104 cubic meters (1.19 x 105 cubic yards) (DOE/NV 1992b).

A RCRA permit is being sought for a proposed Mixed Waste Disposal Unit in the area immediately north of Pit 3 in the Area 5 Radioactive Waste Management Site. This Mixed Waste Disposal Unit would occupy 2.1 x 105 square meters (52 acres) and consist of ten landfill cells. The estimated disposal space for mixed waste in this proposed unit is approximately 1.20 x 105 cubic meters (1.58 x 105 cubic yards) (DOE/NV 1992b).

Figure 4.14-2. Flow diagram for waste generation at the NTS. Figure 4.14-3. Flow diagram for waste shipment, receipt, and disposal at the NTS.

Table 4.14-1. Baseline waste management for 1995 at the NTS.

Waste type	Volume generated or disposed of (m3)	Available disposal space (m3)	Disposition
Transuranic waste and mixed-transuranic waste	0	8,296	Interim onsite storage
Low-level waste	10,845	438,359	Onsite disposal
Mixed low-level waste	0	90,240	Onsite disposal
Hazardous waste	252	91	90-day pad
Sanitary waste	1.1 x 104b	c	Onsite disposal

a. Sources: DOE/NV (1994d, 1992c).

b. 1992 data.

c. Current disposal space adequate.

In May 1990, mixed waste disposal operations ceased due to EPA issuance of the Land Disposal Restrictions of RCRA. Active mixed waste disposal operations will commence under interim status in Pit 3 upon completion of NEPA documentation and an approved Waste Analysis Plan (DOE/NV 1993c). No mixed low-level waste has been received, generated, or disposed of at the NTS since 1991 (DOE/NV 1994d, 1993c,f).

4.14.3 Low-Level Waste

Two low-level waste disposal facilities are in operation at the NTS: Area 5 Radioactive Waste Management Site and the Area 3 Radioactive Waste Management Site (DOE/NV 1992c). The Area 5 Radioactive Waste Management Site receives low-level waste generated at the NTS and other DOE facilities and occupies approximately 2.9 square kilometers (730 acres) of land. The waste is disposed of in large-diameter shafts, trenches, and shallow pits. The total volume of low-level waste disposed of at the Area 5 Radioactive Waste Management Site between 1961 and 1991 was 3.96 x 105 cubic meters (5.8 x 105 cubic yards). Average annual low-level waste disposal for this period was 1.3 x 104 cubic meters (1.7 x 104 cubic yards). During 1993, approximately 1.1 x 104 cubic meters (1.4 x 104 cubic yards) of low-level waste was disposed of at the NTS (DOE/NV 1994d).

4.14.4 Hazardous Waste

The primary facilities that generate or manage nonradioactive hazardous wastes and/or use or store nonradioactive hazardous materials are the Liquified Gaseous Fuels Spill Test Facility, the Hazardous Waste Accumulation Site, the tunneling facilities and operations, and various underground storage tanks.

The Liquified Gaseous Fuels Spill Test Facility is located on Frenchman Lake in Area 5.

This location provides a remote, environmentally acceptable setting for atmospheric release of hazardous materials and toxic substances for investigative purposes. The facility consists of a tank farm, spill area, wind tunnel, and pads for conducting small volume spill tests. The facility also includes a control building that houses data acquisition and recording instruments, a command and control computer, and support personnel. A total of 17 spill tests were conducted at the facility in Area 5. Discharges from the test facility occur at a controlled rate and consist of a measured volume of hazardous test fluid released on a surface especially prepared to meet the test requirements. Personnel monitor and record operating data, close-in and downwind meteorological data, and downwind gaseous concentration levels. Spills involving hydrofluoric acid were conducted in 1991 and the results monitored (DOE/NV 1992c).

The Hazardous Waste Accumulation Site consists of an impervious concrete pad with 15-centimeter (6-inch) curbs to contain spillage and to protect the pad from precipitation runon and runoff; a separate curbed area is provided for noncompatible wastes. A roof protects the wastes from rain and weathering effects; there is also a fire detection system (DOE/NV 1992d). Each operating entity at NTS is a potential satellite accumulation area for hazardous waste. Each satellite accumulation area is allowed to accumulate up to 208.2 liters (55 gallons) of hazardous waste or 0.95 liter (1 quart) of acutely hazardous waste. Within 3 days of reaching these quantities, the waste is transferred to the Hazardous Waste Accumulation Site. If the material is unknown or if an offsite treatment, storage and disposal facility wishes to confirm the contents of a waste stream, samples are collected for characterization (DOE/NV 1992d).

When the waste containers are transferred to the Hazardous Waste Accumulation Site, they are checked for proper labeling and an accumulation date is assigned to each container. An EPA-permitted treatment, storage, and disposal facility is contacted prior to the 90-day storage limit to collect and remove the accumulated wastes from the NTS (DOE/NV 1992d).

Nuclear devices were tested in horizontal tunnels mined into Rainer Mesa at the NTS. The tests were conducted in zeolitized volcanic tuffs, which act as a perching layer for waters infiltrating from the mesa surface. During normal tunneling operations, fractures containing water are intercepted creating artificial springs in the tunnels. Periodically, these waters contain radionuclides from previous underground nuclear tests and are drained out of the tunnels into evaporation ponds or washes. Tunneling and related operations also may have released organic compounds and heavy metals to the tunnel effluent. Presently, sampling of the tunnel effluent is being conducted to characterize the effluent. The objectives of the project include identifying the types and concentrations of radionuclides, metals, and organic compounds in the effluent of U12t, U12e, and U12n tunnels. Variations of discharge volumes and chemical contaminants over time are also being examined (DOE/NV 1992c).

There is a site-wide inventory of 115 underground storage tanks at the NTS. These include 24 underground storage tanks containing petroleum products that were removed, closed in place, or temporarily taken out of service in 1991 in accordance with state statutes as well as 17 underground storage tanks which were temporarily closed in 1991 while awaiting upgrades (DOE/NV 1992c).

As part of the 1991 underground storage tank activities, all tanks to be upgraded had soil samples taken from the tank ends to identify any soil contamination prior to redesign and construction. To date, overfill releases from underground storage tanks located at the Areas 6, 12, and 23 gasoline stations were observed and necessitated additional soil sampling. All underground storage tanks that were planned to be upgraded (except a tank containing asphaltic material) were also pressure tested for leaks. All tanks passed the test limit of 0.76 liter per hour (0.2 gallon per hour) (DOE/NV 1992c).

Numerous underground storage tanks have been identified throughout the site as "Undetermined Activity Status." The contents of some of these underground storage tanks is classified as "H?" which indicates that the contents are presumed to be hazardous.

The types of possible wastes found on the surface of the NTS include radionuclides, organic compounds, metals, hydrocarbons, and residues from plastic, epoxy, and drilling muds (not petroleum production related and therefore considered hazardous under Subtitle C of RCRA). A wide variety of surface facilities, such as injection wells, leach fields, sumps, waste storage facilities, tunnel ponds and muck piles, and storage tanks, may have contaminated the local soil and the shallow unsaturated zone of the NTS. Because of the great depths to groundwater and the arid climate, it is assumed that the potential for mobilization of surface and shallow subsurface contamination is minimal. However, contaminants entering carbonate bedrock from Rainier Mesa tunnel ponds, contaminated wastes injected into deep wells, and wastes disposed into subsurface craters have the potential to reach the regional water table. Pilot wells were to be installed during 1992 to support the RCRA permitting process (DOE/NV 1992c).

Annual generation or disposal of hazardous waste at the NTS was approximately 252 cubic meters (329.6 cubic yards) during 1993. Available storage space on the 90-day pad is approximately 91 cubic meters (119 cubic yards) (DOE/NV 1994d).

4.14.5 Sanitary Waste

Sanitary wastes are expected to be generated at the current rates for several years into the future, then decline assuming the present moratorium on underground weapons testing. Liquid sanitary wastes are disposed of in septic tanks/leach fields, sumps, or in ponds, and solid sanitary wastes are disposed of in landfills at various locations on the site. The NTS currently maintains 13 sewage discharge permits: Area 2, Area 6 (5), Area 22, Area 23, Area 25 (4), and Area 12 (DOE/NV 1993c). Approximately 9.1 x 103 cubic meters (11,902 cubic yards) of sanitary waste were generated at the NTS during 1991 and 1.1 x 104 cubic meters (14,388 cubic yards) during 1992 (DOE/NV 1993c). Sufficient disposal space is available at the NTS for current needs.

4.14.6 Hazardous Materials

Polychlorinated biphenyls, pesticides, and asbestos have been or currently are managed at the NTS. These wastes and materials are managed in addition to the approximately 90,000 kilograms (100 tons) of RCRA-regulated nonradioactive hazardous wastes generated annually at the NTS, the approximately 218,000 kilograms (240 tons) of non-RCRA-regulated hazardous waste generated annually at the NTS, and the wastes and materials managed at the facilities discussed previously.

By the end of 1991, all known polychlorinated biphenyl transformers and other electrical equipment had been either reclassified or appropriately disposed of, and three polychlorinated biphenyl-contaminated transformers and regulators were under the 90-day period for reclassification. Successful reclassification of these three polychlorinated biphenyl-contaminated transformers will complete the reclassification or disposal of all known polychlorinated biphenyl and polychlorinated biphenyl contaminated transformers at the NTS (DOE/NV 1992c).

No unusual environmental activities relating to the Federal Insecticide, Fungicide, and Rodenticide Act occurred in 1991 at the NTS. Pesticides are stored in an approved storage facility located in Area 23. Pesticide usage includes insecticides, herbicides, and rodenticides. Insecticides are applied twice a month at the food service areas, herbicides are applied once a year, and all other pesticides are applied on an as-requested basis. General-use pesticides are used for most applications, although restricted-use herbicides and rodenticides are used on occasion (DOE/NV 1992c).

The Area 11 Explosive Ordnance Disposal Facility is a thermal treatment unit for disposal of conventional explosives. Explosives detonated at the facility include Defense Nuclear Agency materials and waste explosives from Reynolds Electrical and Engineering Co., Inc. tunnel operations, the Wackenhut Firing Range (used by the NTS security force), and the resident national laboratories. No radioactive or radioactive-contaminated materials are accepted or detonated at the Area 11 Explosive Ordnance Disposal unit.

The unit encompasses approximately 0.08 square kilometer (20 acres) of land located between Frenchman Flat and Yucca Flat, with four graded areas. Only one of these graded areas is used for detonation. Magazines are used to store detonation materials and waste explosives. Approximately 80 to 90 percent of the explosives detonated at the Explosive Ordnance Disposal unit during the past 10 to 12 years have been water-gel explosives; earlier, the primary waste was gelatin-based dynamite. Other explosives detonated include small amounts of trinitrotoluene (TNT), RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) pellets, small arms ammunition (from past military operations at NTS), and black powder (DOE/NV 1992b).

4.14.7 Non-hazardous Waste

Solid wastes are regulated through State of Nevada regulations NAC 444 and Federal regulations 40 CFR 241, 257, and 258. Solid wastes generated include used petroleum products, uncontaminated tunnel muck, drilling fluids, cement and grout wastes, construction debris, refuse, sludge from wastewater lagoons, septic tank and chemical toilet sludge, and animal carcasses. The NTS has several sanitary landfills and construction landfills in operation; several landfills have been closed or abandoned (DOE 1990).

Some wastes not regulated under RCRA will be stored at the Hazardous Waste Accumulation Site. These nonregulated wastes are shipped offsite along with the RCRA wastes to a treatment, storage, and disposal facility. Only non-RCRA hazardous wastes that cannot be disposed of at the NTS landfill will be stored at the Hazardous Waste Accumulation Site for offsite shipment. Any drum containing nonregulated wastes will carry a label so specifying. The contents of the drum will be entered on a space provided on the label. Wastes in this category include but are not limited to epoxies, photochemicals, spent antifreeze, and oils and solvents that do not carry EPA codes.

Recycling of paper, metals, glass, plastics, and cardboard has already resulted in some decrease in quantities of waste and is expected to result in significant decreases over the next few years (DOE/NV 1992b).

5. ENVIRONMENTAL CONSEQUENCES

5.1 Overview

This chapter describes the potential environmental consequences from the construction and operation of spent nuclear fuel (SNF) facilities at the Nevada Test Site (NTS) under the Centralization and Regionalization Alternatives. Potential environmental consequences are assessed to the extent necessary to support a programmatic decision concerning the siting of the proposed SNF facilities. More detailed considerations of potential environmental consequences would be performed as necessary prior to initiating construction or operation of the facilities.

5.2 Land Use

5.2.1 Centralization Alternative

Construction and operation of SNF facilities under this alternative would require the disturbance of approximately 90 acres (0.36 square kilometer), including buffer areas. Use of the proposed SNF site for program activities would be consistent with existing nearby land uses and land use policies and plans. The current land use designations for this area are Low-Level Waste Facility Management and Buffer/Reserved Area. Use of this area for program activities would also be consistent with future land use plans (DOE/NV 1993a).

Use of the proposed site for the construction and operation of SNF facilities could result in irreversible or irretrievable land use impacts in those areas currently under Buffer/Reserved use. However, the placement of SNF facilities at this location would be consistent with DOE's 1994 draft future land use plan, which designates this portion of Area 5 as a Non-Nuclear Test Area (DOE/NV 1993a). Therefore, no mitigation measures are proposed.

5.2.2 Regionalization Alternative

As under the Centralization Alternative, use of the proposed site for construction and operation of SNF facilities under the Regionalization Alternative would be consistent with existing land uses and with all applicable land use policies and plans. Impacts would be similar in character to those described for the Centralization Alternative, except that there could be reduced land requirements under this alternative.

5.3 Socioeconomics

Socioeconomics as addressed in this Programmatic Environmental Impact Statement (PEIS) encompasses the interaction of economic, demographic, and social conditions. Economic consequences (e.g., capital requirements to support SNF research and development activities) affect business activities, market structures, procurement methods, and dissemination of commodities within and between regions. Demographic consequences (e.g., in-migration of specialized human resources to support the SNF Management Program) affect size, distribution, and composition of the population, labor force, and the housing market in the regions. Social consequences (e.g., capacity modifications of public infrastructure to support SNF activity) affect the overall quality of life enjoyed by the residents of a community (Murdock and Leistritz 1979). These conditions are potentially affected either directly or indirectly by actions proposed under the U.S. Department of Energy (DOE) SNF Management Program.

The importance of actions is relative to the affected region. A region can be described as a dynamic socioeconomic system, where physical and human resources, technology, social and economic institutions, and natural resources interrelate to create new products, processes, and services to meet consumer demands. The measure of a region's ability to support these demands depends on its ability to respond to changing economic, demographic, and social conditions.

Potential socioeconomic effects are addressed only to the extent that they are interrelated with the natural or physical environment. Direct effects include those impacts that are caused by the action and occur at the same time and place. Indirect effects include those impacts caused by the action that are later in time or farther removed in distance but still are reasonably foreseeable (i.e., offsite) (CFR 1993e). Direct and indirect effects are presented quantitatively from 1995 through 2005, and qualitatively through 2035.

Socioeconomic effects are quantified for regional economic activity and population. Other potential socioeconomic impacts to individual communities, such as public infrastructure and housing, are discussed qualitatively to address programmatic issues.

Economic impact projections include direct and indirect jobs. Direct jobs are those jobs needed to construct or support the operation of the SNF management complex at the NTS.

Indirect jobs are created throughout the regional economy within the Region of Influence as a result of procurement for materials, services, and other commodities, and induced effects from consumer spending. These direct and indirect impacts reflect both construction and operation phase demands, which may occur concurrently or independently throughout the project planning period. Indirect jobs were projected using parameters from the U.S. Bureau of Economic Analysis Regional Input-Output Modeling System.

Two scenarios were analyzed to account for two potential distributions of the SNF facility construction efforts. The construction effort consists of fabricating various structures, each with its own construction labor need and a duration of either three or five years. The Peak Scenario accelerates the construction labor requirements into the first two years of construction. The Average Scenario averages the labor requirements of a structure for the duration of construction. The total construction effort for all structures, in labor years, is the same for each scenario. Therefore, for structures with a three year construction duration, the Peak Scenario has high labor needs for the first two years and then a substantial reduction for the third year, while the Average Scenario has a constant labor requirement for the three years. Likewise, for structures with a five year construction duration, the Peak Scenario has a high labor need for the first two years, then a lower need for the remaining three years, while the Average Scenario has a constant requirement for all five years. Because the total construction labor years for each structure is the same for both scenarios, the Average Scenario will have a lower requirement than the Peak Scenario in the first two years, then will have a higher requirement then the Peak Scenario in the remaining construction years.

Regional population projections reflect the potential change in population resulting from an increase in regional economic activity. Detailed assumptions regarding in-migration associated with the SNF Management Program were not developed, given the programmatic scope of this analysis. Potential in-migration effects resulting from direct job creation are presented qualitatively where appropriate.

5.3.1 Centralization Alternative

The upper and lower bounds of construction and operation-related jobs generated by SNF facilities for both scenarios under the Centralization Alternative from 1995 to 2005 are illustrated in Figure 5.3-1 and tabulated in Table 5.3-1. In its initial phase, the Centralization Alternative may create 54 jobs (25 direct, 29 indirect) over a 5-year period beginning in 1995 and continuing through the year 1999 to support project planning, engineering design, personnel operations training, and environmental permitting and compliance. Construction is expected to begin in the year 2000, requiring a total of 4,351 direct jobs (5,041 indirect jobs). In that year and 2001, the Peak Scenario requires 1,587 construction laborers, while the Average Scenario needs 1,346. There is no operational labor required for this time period. In 2002, after two years of construction, the Peak Scenario decreases its construction labor requirements to 928 workers, while the Average Scenario maintains its 1,346 laborers. Additionally, 300 operational personnel are needed, raising the total of SNF workers to 1,228 for the Peak Scenario and 1,646 for the Average Scenario. By 2003, the buildings with three year construction durations have been completed; therefore, both the Peak and Average Scenario construction labor requirements decline to 125 and 157, respectively. Operation labor requirements remain at 300 workers. Total SNF labor requirements are 425 workers for the Peak Scenario and 457 for the Average Scenario. In 2004, construction labor needs for both scenarios remains at their previous level, but operational personnel increase. Total SNF labor requirements are 612 workers in the Peak Scenario and 644 workers in the Average Scenario. By 2005, all construction has been completed and operational personnel have increased to the full staff labor requirement of 800 workers.

The Peak Scenario reaches its maximum construction labor with 1,587 direct jobs (3,426 total jobs created) over a 2-year period from years 2000 through 2001. The Average Scenario would have its maximum construction labor with 1.346 direct jobs (2,906 total jobs created) in a

Figure 5.3-1. Total employment effects, NTS centralization alternative.

Table 5.3-1. Socioeconomic effects - centralization of SNF at Nevada Test Site.

	Time period					
Years	1995 - 1999	2000, 2001	2002	2003	2004	2005 +
			Operations			
Direct jobs	25	0	300	300	487	800
Indirect jobs	29	0	344	344	559	918
Total jobs	54	0	644	644	1,046	1,718
			Construction			
Direct jobs						
Peak	0	1,587	928	125	125	0
Average	0	1,346	1,346	157	157	0
Indirect jobs						
Peak	0	1,839	1,076	145	145	0
Average	0	1,560	1,560	182	182	0
Total jobs						
Peak	0	3,426	2,004	270	270	0
Average	0	2,906	2,906	339	339	0
			Total			

Direct jobs						
Peak	25	1,587	1,228	425	612	800
Average	25	1,346	1,646	457	644	800
Indirect jobs						
Peak	29	1,839	1,420	489	704	918
Average	29	1,560	1,904	526	741	918
Total jobs						
Peak	54	3,426	2,648	914	1,316	1,718
Average	54	2,906	3,550	983	1,385	1,718
Population Change						
Peak	91	5,664	(1,084)	(2,379)	547	540
Average	91	4,804	896	(3,522)	547	447

3-year period from years 2000 through 2002. Operation requirements would be minor until 2002, when engineering and administrative services are assumed to be in demand to accommodate project requirements. Ancillary SNF complex operations, such as utilities and research and development activities, are assumed to begin in 2004, taper off into 2005, and remain relatively constant through 2035. The maximum total SNF management direct jobs under either construction scenario would occur in 2002 with 1,346 construction jobs for the Average Scenario and 300 operation jobs. Implementation of the Centralization Alternative would increase the projected average annual rate of growth rate for both regional population and employment from 1995 through 2005 by 0.02 percent.

Regional businesses and the work force would benefit from increased competition for contract procurement and jobs. Most of this activity is anticipated to be captured by Clark County, with a smaller share occurring in Nye County. However, the impact to the regional economy represents only a portion of the total economic activity generated by the Centralization Alternative. For instance, purchases of specialized materials and technology acquisition may occur even outside the State of Nevada. It has been estimated that about 50 percent of total NTS expenditures occur within the State of Nevada (Nye County Board of Commissioners 1992). This leakage would result in the associated economic benefits accruing outside of the regional economy.

Most of the population change in the Region of Influence above the baseline forecast would be due to in-migration of labor and households to support SNF management activity at the NTS. It is likely that most of the SNF operation work force would be supplied by SNF personnel relocating from DOE sites where SNF inventories were stored before shipment to the NTS, since they are familiar with the processes, technologies, and research. Other demands for operational jobs not related to SNF management would be accommodated by the regional labor market. The regional labor market could accommodate most of the construction requirements, with the exception of very specialized tasks. Construction employment in Clark County is twice that of the national average. As the population continues to grow, demand on public infrastructure grows as well. These projects will result in continued growth in construction activity (Las Vegas Review Journal et al. 1993).

To assess potential population and housing impacts, an in-migration rate per job was estimated using a ratio between projected employment and population figures (Table 4.3-1). This ratio was applied to the number of total (direct and indirect) jobs created by SNF management activities at the NTS, resulting in the total estimated number of persons in-migrating into the Region of Influence per job created (Table 5.3-1).

With initial operation in 1995 under the both scenarios (Table 5.3-1) a total of 91 persons could migrate into the Region of Influence. The number of persons coming in would be at its largest for the years 2000 through 2001, (5,664 in-migrants for the Peak Scenario and 4,804 for the Average Scenario) the period when construction starts. In the final phases of construction, people would migrate out of the Region of Influence. However, the number of in-migrants would increase in the years 2004 and 2005, as more of the SNF management operations start. After 2005, in-migration due to SNF management activities would cease, since SNF management activities would not create any more jobs.

Construction of the SNF complex could result in a temporary increase in housing demand in Nye County. The demand for both the rental market and short-term lodging could increase. The demands on housing would fluctuate over time, based on the various construction phases, peak employment levels, the level of local sub-contracting, and any decision by a contractor to develop temporary housing arrangements near the job site. Within Nye County, the communities of Tonopah and Beatty would probably experience the most impacts related to housing demand. Both communities support fairly large inventories of temporary housing. While such demands are favorable for local lodging operators and landlords, they could compete with tourism demands (Nye County Board of Commissioners 1992).

Overall socioeconomic impacts to Clark County could be absorbed within the projected expansion of the county's economy, local infrastructure, public service, and real estate development.

5.3.2 Regionalization Alternative

Socioeconomic impacts resulting from the Regionalization Alternative are expected to be similar to those for the Centralization Alternative. The construction and operation cycles for each alternative would be the same; therefore, the same issues identified for the Centralization Alternative would apply. Labor requirements might be reduced slightly for the Regionalization Alternative. Although the volume of SNF stored would be less for the Regionalization Alternative, an economy of scale occurs for both alternatives, so that differences in labor and capital between the two alternatives would be minimized.

5.3.3 Mitigation Measures

5.3.3.1 Coordination with Local Jurisdictions. To reduce construction- and operation-

related impacts, possible coordination with local communities could address potential impacts from increased labor and capital requirements. The knowledge of the extent and effect of growth due to SNF management activities could greatly enhance the ability of affected jurisdictions to plan effectively. Effective planning would address changes in levels of service for housing, infrastructure, utilities, transportation, and public services and finances.

5.3.3.2 Enhance Labor Force Availability. To alleviate potential impacts associated with

the in-migration of labor, local labor force availability could be increased through various employment training and referral systems currently provided by the NTS. The goal of these systems would be to reduce the potential for in-migration of labor to support SNF management activities.

5.4 Cultural Resources

5.4.1 Centralization Alternative

Under the Centralization Alternative, the construction of SNF facilities is not expected to require the disturbance of more than 90 acres (0.36 square kilometer) on the NTS. There are no known historical, archeological, paleontological, or Native American traditional sites in the proposed area or its vicinity. Therefore, no impacts to cultural resources are expected due to ground disturbance, noise, or air emissions during construction and operation of the SNF facilities. Consultation with the Nevada State Historic Preservation Office (SHPO) prior to project implementation is required under Section 106 of the National Historic Preservation Act of 1966. The SHPO may recommend that further archaeological studies be conducted throughout the construction area to verify that there are no archaeological sites subject to disturbance.

5.4.2 Regionalization Alternative

Under the Regionalization Alternative, the location of the SNF facilities would remain the same but could be reduced in area. As with the Centralization Alternative, impacts are not anticipated.

5.5 Aesthetics and Scenic Resources

5.5.1 Centralization Alternative

The proposed SNF facilities under the Centralization Alternative, when fully constructed and under operation, would consist of a series of industrial buildings set within a security fence on the proposed 90-acre (0.36 square-kilometer) site. The facility would have the appearance of industrial buildings ranging in height from one to three stories. The maximum height of the buildings contained within the site would not exceed 42 feet (13 meters) above ground level. The proposed SNF site is located within a valley over 10 miles (16 kilometers) from U.S. Route 95, separated by intervening hills and mountains, including Red Mountain, the Spotted Range, the Specter Range, Hampel Hill and Skull Mountain. The site would not be visible from areas outside the NTS or the Nellis Air Force Base Bombing and Gunnery Range. Therefore, impacts to aesthetics and scenic resources are not anticipated.

5.5.2 Regionalization Alternative

Under the Regionalization Alternative, proposed SNF facilities could be reduced in area and intensity of operations from the Centralization Alternative. Environmental effects to aesthetics and scenic resources could also be less than that of the Centralization Alternative.

5.6 Geologic Resources

This section describes any incremental or additional impacts on geology and geologic resources that would result from the construction and operation of the new facilities associated with the storage of SNF at the NTS. Seismic and volcanic hazards are discussed in Section 4.6.

5.6.1 Centralization Alternative

As discussed in Section 4.6.2, precious metal deposits may exist in certain carbonate rocks and volcanic or sedimentary rocks at the NTS. Figure 4.6-5 shows the proposed SNF site in relation to these types of geologic terranes as well as to the locations of mining districts. Although the proposed SNF facilities would not be located within a mining district, they would be situated on Tertiary volcanic or sedimentary rocks near volcanic or intrusive centers (the type of geologic terrane where small to medium-size precious metal deposits could be developed). However, because the NTS would likely remain closed to mining operations, the impact on any precious metal deposits that might exist at the NTS would not change if the proposed storage facility were to be sited there.

In addition, destruction of unique geologic features are not expected to occur as a result of construction and operation of a new SNF storage facility nor are mass movement and subsidence and sediment runoff from land disturbances.

5.6.2 Regionalization Alternative

Impacts to geology and geological resources under the Regionalization Alternative would generally be as described for the Centralization Alternative.

5.7 Air Resources

Both radiological and nonradiological air emissions impacts from the proposed SNF facilities are discussed in this section.

5.7.1 Centralization Alternative

5.7.1.1 Emissions.

5.7.1.1.1 Radiological Emissions-There would be no radiological emissions from

construction of the proposed SNF facilities.
The total annual airborne radionuclide releases from operation of the proposed SNF facilities are provided in Table 5.7-1.

5.7.1.1.2 Nonradiological Emissions-During construction of the proposed SNF

facilities, short-term emissions, such as fugitive dust and heavy equipment exhaust emissions, would be temporary and only affect receptors close to construction areas.
Fugitive dust emissions would be minimized by curtailing soil-disturbing activities during high winds. During operation of the proposed SNF facilities, criteria and hazardous air pollutants would be emitted.

The total annual emissions from all modules associated with the proposed SNF facilities are listed in Table 5.7-2.

5.7.1.2 Air Quality.

5.7.1.2.1 Radiological-The GENII environmental transport and dose assessment

model (PNL 1988) was used with 1990 meteorological data from Desert Rock Army Airfield to determine effective dose equivalents from the radiological emissions listed in Table 5.7-1. A population of 15,100 persons was estimated to be within 50 miles (80 kilometers) of the proposed SNF facilities. It was also assumed that 1995 operations at the NTS would result in the same baseline radiological emissions as the 1992 operations at the NTS. The most recent comprehensive radiological emissions report at the NTS was based on 1992 operations.

Table 5.7-1. Annual airborne radionuclide emission source terms for proposed NTS SNF facility operational phase.

Isotope	Release rate (Ci/yr)b,c
Tritium	7.9 x 10-1
Carbon-14	1.2 x 100
Manganese-54	2.2 x 10-8
Cobalt-60	4.2 x 10-8
Krypton-85	1.0 x 104
Strontium-90	3.3 x 10-6
Yttrium-90	2.0 x 10-6
Ruthenium-106	1.1 x 10-5
Antimony-125	3.4 x 10-4
Iodine-129	1.0 x 10-1
Cesium-134	6.2 x 10-8
Cesium-137	4.8 x 10-5

a. Source: Johnson (1994).

b. 2.0 x 10-6 Ci/yr of Barium-137m, from Wet Storage, is not in GENII. Barium-137m, with a half-life of 2.55 min, decays to Barium-137, which is stable.

c. 7.5 x 10-8 Ci/yr of Thallium-208, from Wet Storage, is not in GENII. Thallium-208, with a half-life of 3.10 min, decays to Lead-208, which is stable.

Table 5.7-2. Total annual nonradioactive emissions for the SNF storage facility at NTS.

Criteria pollutants	Release rate (kg/yr)
Carbon monoxide	1.7 x 103
Particulate matter (PM10)b	1.0 x 10-3
Nitrogen oxides	5.5 x 103
Sulfur dioxide	1.3 x 102
Lead	5.0 x 10-9
Hazardous air pollutants	Release rate (kg/yr)
Selenium compounds	1.6 x 10-4
Mercury compounds	5.1 x 10-1
Chlorine	3.5 x 103
Hydrogen fluoride	1.6 x 101
Cadmium compounds	2.9 x 10-7
Cobalt, chrome, antimony, and nickel compounds	2.0 x 10-10

a. Source: Johnson (1994).

b. All suspended particulate matter is assumed to be PM10.

Table 5.7-3 summarizes the sum of the baseline and the incremental contribution from the proposed SNF facilities to the effective dose equivalents of the maximum site boundary individual and, collectively, to the population within 50 miles (80 kilometers) of the proposed facility. These combined effective dose equivalents for operation of the proposed SNF facilities would be less than 1 percent of the National Emissions Standards for Hazardous Air Pollutants (NESHAP) standard and less than 1 percent of the natural background radiation.

5.7.1.2.2 Nonradiological-The Industrial Source Complex Short Term air

dispersion model (EPA 1992) was used with 1990 meteorological data from Desert Rock Army Airfield to determine pollutant concentrations resulting from the Centralization Alternative nonradiological emissions listed in Table 5.
7-2. A maximum emissions baseline was established to characterize conditions that could result if all sources operated to the maximum extent allowed by permit conditions. It was also assumed that 1995 operations at the NTS would result in the same baseline nonradiological emissions as the 1990 operations at the NTS. The most recent comprehensive nonradiological emissions report at the NTS was based on 1990 operations. The results of modeling are in Table 5.7-4, where a comparison of the existing DOE site contribution concentration is compared to the existing DOE site contribution concentration plus the proposed SNF contribution. The increases in pollutant concentrations from operation of the proposed SNF facilities would be negligible in magnitude. The concentrations of pollutants at the NTS with the inclusion of the proposed SNF facilities would remain within regulatory guidelines.

The calculated atmospheric maximum concentrations at the site boundary and offsite for the proposed SNF facilities are presented in Table 5.7-5. The maximum concentrations at the site boundary reflect exposure to a maximally exposed individual, whereas the maximum onsite concentrations reflect exposure to a worker.

5.7.2 Regionalization Alternative

As with the Centralization Alternative, construction of the proposed SNF facilities under the Regionalization Alternative would not result in radiological air emissions, but could result in minor, temporary emissions of fugitive dust. These emissions could be slightly less than under the Centralization Alternative, since the extent of construction disturbance would be less.

Table 5.7-3. Summary of effective dose equivalents to the public from proposed SNF storage facility plus 1995 baseline operations at NTS.

	Maximally exposed individual doseb	Collective dose to population within 80 km of NTS sources
Dose	1.3 x 10-1 mrem per yearc	8.7 x 10-2 person-remd
NESHAP standard	10 mrem per year	--
Percentage of NESHAP standard	1.3	--
Natural background dose	278 mrem per year	4190 person-rem per year
Percentage of natural backgroun dose	4.7 x 10-2	2.1 x 10-3

a. Effective dose equivalents computed using GENII (PNL 1988).

b. The maximum boundary dose is to the hypothetical individual who remains in the open continuously during the year at the NTS boundary.

c. The SNF facility contributes 1.2 x 10-1 millirem to this dose.

d. The SNF facility contributes 8.2 x 10-2 person-rem to this dose.

Table 5.7-4. Comparison of baseline concentrations with most stringent applicable regulations and guidelines at NTS for proposed SNF facility plus current operations.

Criteria pollutant	Averaging time	Most stringent regulation or guidelined (-g/m3)	Maximum background concentration (-g/m3)	Total existing maximum concentratione (-g/m3)	Total projected maximum concentrationf (-g/m3)	Increase in maximum concentration (-g/m3)
Carbon dioxide	8-hour	10,000	2,290	2,290	2290.8	0.80
	1-hour	40,000	2,748	2,748b	2754.0	6.03
Nitrogen dioxide	Annual	100	a	b	0.20	0.20
Lead	Calendar quarter	1.5	a	b	3.7 x 10-12	3.7 x 10-12
Particulate matt (PM10)c	Annual	50	a	0.43	0.43	0
	24-hour	150	78.3	84.9	84.9	0
Sulfur dioxide	Annual	80	a	1.1	1.1	0
	24-hour	365	39.3	55.2	55.2	0
	3-hour	1,300	65.4	170.3	170.3	0

Hazardous air pollutants						
Selenium	8-hour	4.8	a	b	2.18 x 10-7	2.18 x 10-7
Mercury compounds	8-hour	0.2	a	b	2.18 x 10-3	2.18 x 10-3
Chlorine compounds	8-hour	71.4	a	b	1.52	1.52
Hydrogen fluorid	8-hour	59.5	a	b	3.70 x 10-3	3.70 x 10-3
Cadmium compounds	8-hour	1.2	a	b	1.81 x 10-9	1.81 x 10-9
Cobalt, chromium antimony, and nickel compoundsg	8-hour	1.2	a	b	5.5 x 10-10	5.5 x 10-10

a. Not measured.

b. No sources indicated.

c. All suspended particulate matter is assumed to be PM10.

d. Criteria pollutant regulations are National Ambient Air Quality Standards. Hazardous air pollutant regulations are Nevada Ambient Air Quality Standards.

e. Includes background concentration plus existing DOE facilities impact concentration. This is the baseline concentration.

f. Includes background concentration plus existing DOE facilities impact concentration plus SNF facilities impact concentration.

g. Individual emission rates were not specified for each of cobalt, chrome, antimony, and nickel compounds. Only a total emission rate for all four was provided. Therefore, the most stringent standard for any of the four compounds, 1.2 -g/m3 for cobalt, was used.

Table 5.7-5. Calculated annual maximum concentrations for hazardous air pollutants at NTS, onsite and offsite.

Hazardous air pollutant	Maximum annual average concentration onsite (-g/m3)	Maximum annual average concentration offsite
Selenium compounds	6.03 x 10-8	1.20 x 10-8
Mercury compounds	6.03 x 10-4	1.20 x 10-4
Chlorine compounds	4.2 x 10-1	8 x 10-2
Hydrogen fluoride	1.02 x 10-3	2.04 x 10-4
Cadmium compounds	5.01 x 10-10	1.0 x 10-10
Cobalt, chromium, antimony and nickel compounds	1.50 x 10-10	3.00 x 10-11
Lead	1.21 x 10-11	2.40 x 10-12

a. All impacts from proposed source only. No hazardous air pollutant emissions information available for existing sources.

The same types of radiological and nonradiological air emissions from operation of the proposed SNF facilities would occur under the Regionalization Alternative as under the Centralization Alternative. However, the magnitudes could be lower. As with the Centralization Alternative, the combined dose equivalents from the operation of the proposed SNF facilities would be less than 1 percent of the NESHAP and less than 1 percent of the natural background radiation. The concentrations of non-radiological air emissions from the operation of the proposed SNF facilities under this alternative would remain within all applicable regulatory guidelines (EPA 1992; PNL 1988).

5.8 Water Resources

Construction and operation of the SNF modules could affect surface and groundwater resources. Potential environmental impacts to surface water and groundwater resources during construction include depletion of groundwater supplies, floodplain encroachment, and surface water sedimentation from erosion runoff occurring after land clearing. Potential normal operational impacts could include depletion of groundwater supplies and diminished surface water and/or groundwater quality resulting from wastewater discharges from normal operations.

5.8.1 Centralization Alternative

Separate discussions are provided for surface water quantity, surface water quality, groundwater quantity and groundwater quality.

5.8.1.1 Surface Water Quantity. Existing activities on the NTS derive their water supply

from groundwater sources, and the same would be true for construction and operation of the proposed SNF facilities. Therefore, construction and operation of the proposed SNF facilities would have no impact on surface water availability in the region. In addition, under normal operating conditions, there would be no wastewater discharges to Area 5 watercourses which could affect surface water flow characteristics.

Stormwater runoff associated with construction and operation of the proposed SNF facilities is expected to have a negligible impact on surface water quantity. During construction, standard stormwater management techniques would be employed to attenuate runoff. The impact of stormwater runoff on the ephemeral character of Area 5 watercourses during operation of the SNF facilities is also expected to be negligible. A site drainage and stormwater management system consisting of a perimeter drainage ditches and a retention pond would be included as part of the SNF facilities (Johnson 1994). This system would provide for control of runoff and erosion, which otherwise could affect Area 5 watercourses or the SNF facilities.

As discussed in Section 4.8.1, analyses of available data indicate that the areas encompassed by the proposed SNF facility may lie in flood Zone X (100-year flood zone with depths less than 1 foot [0.30 meter]) and/or Zone AO (100-year flood zone with depths between 1 and 3 feet [0.30 and 0.9 meter]) associated with the Halfpint Alluvial Fan. Accordingly, the SNF facilities would have to be located and constructed to minimize floodplain impacts and to avoid floodplains to the maximum extent possible, as required by Executive Order 11988 (Floodplain Management) and DOE Orders. Site-specific surveys would be performed to determine locations of flooding elevations more accurately.

5.8.1.2 Surface Water Quality. The proposed SNF facility in the northeast portion of

Area 5 is not served by the NTS sanitary sewer system. A number of NTS facilities have self-contained sanitary sewer systems. The nearby Radioactive Waste Management Site does have its own septic tank and leach field system to dispose of sanitary wastewater (DOE/NV 1993a). The proposed SNF facilities would have a sanitary sewer system comprised of a sewage treatment facility equipped with a sewage treatment and ejection pump system with a programmable controller and software. A pressurized sanitary sewer line would be provided to run to a sewage lagoon at the facility (Johnson 1994). This system would be adequate to accommodate the estimated 9,863 gallons (37,335 liters) per day of sanitary wastewater generated by the SNF facilities and personnel. This system would be operated in accordance with State of Nevada permitting requirements.

The proposed SNF facilities are designed to generate no liquid releases of wastewater with hazardous chemicals or radiological characteristics related to SNF management operations. These facilities would be constructed using state-of-the art technologies including secondary containment, and leak detection and water balance monitoring equipment. The normal operation of the proposed SNF facilities is not expected to affect the quality of any surface water
on or near the NTS.

During construction, 90 acres (0.36 square kilometer) would be disturbed, all of it in previously undisturbed areas. This would create the potential for increased sediment runoff into dry washes and shallow drainages or to spread out overland as a result of sheetflow. However, sediment runoff from construction activities would be controlled by implementing soil erosion control measures, which would result in negligible effects to surface water quality.

In addition, as stated in Section 4.8.1, existing onsite contaminants may be transported and dispersed beyond the facility boundary during flooding (USAF et al. 1991). Therefore, the potential exists for some incremental transportation and dispersion of any additional contaminants that might result from the construction or operation of the SNF facilities. Although
this potential cannot be determined without additional studies, any additional contamination would be unlikely, due to the design of the containment structures and leak detection system of the SNF facilities.

5.8.1.3 Groundwater Quantity. Operation of the SNF facilities would require

approximately 9,863 gallons (37,335 liters) per day. This translates to an additional 3,600,000 gallons (13,627 cubic meters) of water used at the NTS per year. It is assumed that the water demand of the SNF facilities would be supplied via the existing NTS Area 5 supply wells and water distribution system. If this scenario should be demonstrated to be infeasible or impractical,
a water supply and distribution system consisting of two 8-inch-diameter wells supplying two

250,000-gallon (946,333-liter) aboveground storage tanks would be constructed to service the SNF facility complex (Johnson 1994).

Water withdrawals to support the proposed SNF facilities would likely be from the Frenchman Flat hydrographic area of the Ash Meadows Subbasin. In 1993, 176 million gallons (666,000 cubic meters) of groundwater was withdrawn by DOE from the Frenchman Flat hydrographic area. An additional 3.6 million gallons (14,000) cubic meters) per year would be required for SNF operations. The recharge due to precipitation in the Frenchman Flat hydrographic area was estimated to be 32.6 million gallons (123,000 cubic meters) (Rush 1970). This recharge estimate was exceeded for more than thirty years with no decline in static water levels (DOE 1988b). Accurate measurement of static water levels are, however, precluded by numerous conditions on the NTS (Winograd 1970). More detailed analyses of perennial yield and total water withdrawal from the hydrographic area would be required if the NTS were chosen as a site for SNF management facilities, but because the estimated perennial yield has been exceeded for more than thirty years with no measurable decline in static water levels, it is likely that increased water use for the SNF Management Facility could be sustained.

Because of hydrogeologic complexities, a regional groundwater flow at the NTS is not constrained by the hydrographic basins which are defined by local topography (USAF et al. 1991). Therefore any potential groundwater overdrafts in the Frenchman Flat hydrographic area indicated by previous yield estimates are likely made up by untapped groundwater from neighboring hydrographic areas. Localized impacts could occur if the perennial yield of Frenchman Flat hydrographic area is exceeded. Potential impacts include depletion of water stored locally in the regional aquifer, removal of that groundwater from other potential uses, and the potential modification of the rate and direction of contaminant migration resulting from underground nuclear testing. The complex issues of groundwater contamination and use are being addressed in the Resource Management Plan being prepared in conjunction with the NTS site-wide EIS.

The vast majority of groundwater not withdrawn from the Frenchman Flat hydrographic area, and the Ash Meadows Subbasin as a whole, is discharged at Ash Meadows. Using 1993 water withdrawal data, NTS annual withdrawal from the Ash Meadows Subbasin would only increase by 1% or 3.6 million gallons (14,000 cubic meters) to approximately 370 million gallons (1.4 million cubic meters) if the proposed SNF facilities were sited on NTS. This increase in withdrawal would have little impact on the subbasin as a whole as its perennial yield is estimated to be 12 to 18 billion gallons (46 to 68 million cubic meters) (DOE 1988b; USAF et al. 1991). Water from the groundwater systems which pass beneath the NTS annually discharge approximately 8.8 billion gallons (33 million cubic meters) to the deserts southwest of the NTS (DOE/NV 1993b). Annual groundwater withdrawal for SNF operations would amount to 0.04 percent of this discharge. No impacts to down-gradient users and discharge areas would be expected due to the small volume of water required and the vast amount of water in the regional groundwater system.

Dewatering is not expected to be necessary to construct the SNF facility complex, due to the relatively great depth to groundwater across the NTS. Although perched water table conditions at depths of 70 feet (21 meters) have been reported for Frenchman Flat, all excavation activities are expected to occur in the vadose zone. Consequently, there would be no effect on groundwater quantity due to construction dewatering of wastewater with hazardous chemical or radiological characteristics related to SNF management activities.

5.8.1.4 Groundwater Quality. As previously mentioned, the proposed SNF facilities are

designed to have no liquid release to the environment. However, for the purpose of this water resource analysis, a conservative release scenario was evaluated to identify the potential environmental consequences of a liquid release to the environment under normal operating conditions. The release scenario was evaluated for information purposes only, as no normal operating releases are planned for the proposed facility. The scenario consisted of a maximum potential liquid release to the environment under normal operating conditions such as an undetected secondary containment failure or piping leak. The scenario was evaluated using conservative estimates of the sensitivity of actual leak detection systems and operational source term data from similarly functioning facilities at the Idaho National Engineering Laboratory (INEL). The conservative estimates for the hypothetical release included a point release of 5 gallons (19 liters) per day to the environment over the course of 1 month. The release volume and durations were considerably greater than existing leak detection system sensitivities, surveillance activities, and radiological surveys. Source terms were derived at the 95 percent confidence level from 8 years of operational data at the INEL Fluorinel and Storage Facility at the Idaho Chemical Processing Plant.

The point source release as described above has been conservatively assumed to occur at a depth of 40 feet (12 meters) below land surface (the bottom of the Wet Storage Basin for the Receiving/Canning Facility). As detailed in Section 4.8.2, this is well within the vadose zone underlying Area 5 at Frenchman Flat. Vertical flow in the uppermost portions of the vadose zone at Area 5 is generally upward toward the surface, due to an extremely high evapotranspiration rate relative to precipitation. Site characterization data for Area 5 indicate that the vertical flow direction in the vadose zone is upward from 0 to 75 meters (0 to 250 feet) below land surface. In the next interval (75 to 180 meters [250 to 600 feet]), a downward flow rate of 3 meters/1,000 years (10 feet/1,000 years) has been calculated. At a depth of 180 to 250 meters (600 to 800 feet), a zone of equilibrium is present above the water table (a zone of no vertical movement). These data, combined with the relatively extensive depth to the water table (244 meters [800 feet]) and extreme travel times to the water table, indicate that the release described above would be highly unlikely to reach the saturated zone. The release would likely remain indefinitely in the vadose zone beneath the proposed SNF facilities, where it would present a persistent source of contamination but would not affect groundwater quality.

5.8.2 Regionalization Alternative

Potential impacts to surface water and groundwater from construction and operation of the proposed SNF facilities under the Regionalization Alternative would generally be as described for the Centralization Alternative. However, the quantity of groundwater withdrawn to support operation of the proposed facilities could be less.

5.9 Ecological Resources

The Centralization and Regionalization Alternatives could potentially affect ecological resources primarily through the alteration or loss of habitat. Potential impacts to terrestrial and aquatic resources and threatened and endangered species are described below for both alternatives.

Radiation doses received by terrestrial biota from waste management activities would be expected to be similar to those received by humans. Although guidelines have not been established for acceptance limits for radiation exposure to species other than humans, it is generally agreed that the limits established for humans are also conservative for other species (NRC 1979). Evidence indicates that no other living organisms have been identified that are likely to be substantially more radiosensitive than humans (Casarett 1968; National Academy of Sciences 1972). Additionally, work areas where potential radiation exposure is high and monitored site workers utilize protective equipment, have controlled access measures which limit entry by biota. Thus, so long as exposure limits protective of humans are not exceeded, no substantial radiological impact on populations of biota would be expected as a result of waste management activities at the proposed SNF facility.

5.9.1 Centralization Alternative

Under this alternative, 90 acres (0.36 square kilometer) of the creosote bush plant community would be disturbed during construction. The area disturbed would include construction laydown areas, grading, and new buildings. In addition, disturbance would be expected along access roads and other rights of way which have not been included in the 90 acres. This plant community is common to the southern portion of NTS. To obviate any impacts to this plant community, ground-disturbing activities would be kept to a minimum. This would also serve to reduce the number of non-native species, such as Russian thistle, to the area. However, non-native species would probably become established in some areas, for example, along the access road.

Impacts to wildlife would occur as a direct result of habitat loss and/or an indirect result of increased human presence. There could be a decrease in the number of small mammals and reptiles during the construction period due to ground-disturbing activities. More mobile animal species would be able to move to other areas on the NTS during construction. Depending upon the carrying capacity of these areas, there could be increased competition for food and water resources. After construction activities are complete, it is expected that species which adapt to developed areas would become established.

Impacts to birds protected under the Migratory Bird Treaty Act are expected to be minimal during construction, since there are no water sources at the proposed site. However, surveys prior to construction may be required by the U.S. Fish and Wildlife Service. During operation, there may be an increase in migratory birds utilizing the area due to the increase in water sources.

There would be no impact on wetlands or aquatic habitats due to the construction of the facility because these habitats do not exist in the area. The operation of the proposed SNF facilities would increase water sources for wildlife species due to retention ponds and a sewage lagoon area. This could bring an increase in species, especially migratory birds, seeking aquatic habitats. The addition of new species to the area would impact upon the general ecology by increasing diversity of species. Since these areas would be within fenced enclosures, it is expected that the larger mammals would be unable to directly utilize these water sources.

Noise and activity associated with construction would be expected to have short-term effects on most wildlife. Studies on the effects of noise on wildlife have shown varying responses by different species. Responses include becoming frightened and running away, altering migration or breeding patterns, changing home ranges (often decreasing them), or adapting to the noise and activity (EPA 1980). These effects would continue indefinitely during the operating life of the proposed SNF facilities.

Potential impacts to threatened and endangered species would be the direct result of increased human presence and the loss or alteration of habitat. Any Federal Candidate or state-protected species on the site would result in further consultation with the U.S. Fish and Wildlife Service and the Nevada State Forester. Mitigation plans would be developed in cooperation with the appropriate agencies if any of these species were identified on the project site.

Although positive identification of most of the species listed on Table 4.9-1 has not occurred during prior studies, the addition of water sources to the area could increase the suitability of habitat for some endangered, threatened, or candidate bird species. These might include birds of prey (bald eagle, peregrine falcon, ferruginous hawk, and golden eagle), and species which inhabit water areas such as shorebirds (mountain plover, western least bittern, western snowy plover, and white faced ibis). An increase in loggerhead shrikes may occur due to the fencing that would be erected around the facility and would serve as posts for this bird.

The project area is located within the range of the desert tortoise, a federally listed threatened species. Recent pre-activity surveys for other nearby projects have not identified the desert tortoise in the general area of the project site. However, a pre-activity survey for this project would be needed to determine the presence or absence of the desert tortoise and other species of concern. If present, the desert tortoise could be impacted during construction of the proposed SNF facilities due to increased vehicular traffic, construction of trenches for utilities, and other temporary construction excavations. Prior to and during construction activities, fencing of the areas and removal of tortoises within the fence would decrease the potential to bring harm to the desert tortoise. All activities with this species must be completed by a qualified biologist.

5.9.2 Regionalization Alternative

Impacts under this alternative are expected to be generally the same as under the Centralization Alternative. The major difference between the two is the total area to be disturbed. The Regionalization Alternative is expected to involve construction of fewer buildings and, therefore, to require disturbance of less land.

5.10 Noise

As discussed in Section 4.10, noises generated on the NTS do not propagate offsite at levels that impact the general population. Thus, the NTS noise impacts for both the Centralization and Regionalization Alternatives would be limited to those resulting from the transportation of personnel and materials to and from the site, which affect the nearby communities, and those resulting from onsite sources which may affect some wildlife near these sources. The effect of noise on wildlife near SNF management facilities under the Centralization or Regionalization Alternatives would be addressed in a project-specific environmental assessment.

The transportation noises are a function of the size of the work force (e.g., an increased work force would result in increased employee traffic and corresponding increases in deliveries by truck and rail, and a decreased work force would result in decreased employee traffic and corresponding decreases in deliveries). The analysis of traffic noise took into account noise from the major roadway which provides access to the NTS. Vehicles used to transport employees and personnel on roadways would be the principal sources of community noise impacts near the NTS from the Centralization and Regionalization Alternatives.

This analysis used the day-night average sound level to assess community noise, as suggested by the U.S. Environmental Protection Agency (EPA 1982, 1974) and the Federal Interagency Committee on Noise (FICON 1992). The change in the day-night average sound level from the baseline noise level for each alternative was estimated based on the projected change in employment and traffic levels from the baseline levels. The baseline is comparable to current activity at the NTS for 1993. The combination of construction and operation employment was considered. The traffic noise analysis considered U.S. Route 95, which employees use to access the NTS from Las Vegas. Changes in noise level below 3 decibels would not be expected to result in a change in community reaction (FICON 1992).

5.10.1 Centralization Alternative

Under the Centralization Alternative, the projected NTS work force would increase by about 48 percent of existing onsite employment in the years 2000 to 2002, the peak construction period, and decrease thereafter (Section 5.3). There would be a corresponding increase in truck, private vehicle, and bus trips. The day-night average sound level at 50 feet (15 meters) from U.S. Route 95 would be expected to increase by about 1 decibel. No change is expected in the community reaction to noise along this route. No mitigation efforts are necessary.

5.10.2 Regionalization Alternative

Under the Regionalization Alternative, traffic noise impacts would be the same as for the Centralization Alternative.

5.11 Traffic and Transportation

The proposed SNF management activities would involve a small increase in the number of employees commuting to the NTS and the transportation of SNF and hazardous chemicals on the NTS. This section summarizes potential transportation impacts due to the proposed SNF facilities on the NTS.

5.11.1 Centralization Alternative

5.11.1.1 Levels of Service. Levels of service were calculated for construction and

operation of the SNF facility at the NTS. The maximum reasonably foreseeable scenario for construction and operations occurs when the combined number of employees and population are at their highest. This would occur in 2001, when there would be 3,426 employees and a projected baseline population in the Region of Influence of 1,209,316. The Region of Influence includes Nye and Clark counties. Direct employees associated with the proposed SNF facility generate direct trips in the Region of Influence. These trips are distributed to the Region of Influence road network according to percentages based on a traffic flow between the site and where employees historically have lived. Increases in baseline population and indirect site-related employees generate indirect trips in the Region of Influence. These trips are distributed based on the current average daily traffic per present population in the region of influence for a given segment. Direct and indirect average daily traffic are added and a new level of service is determined. Construction and operation employees contribute little to the future traffic because they represent such a small percentage of the Region of Influence population growth.

None of the future baseline levels of service would change due to SNF-related impacts.

5.11.1.2 Rail Transportation. The generic facility design would require rail access for

Naval fuel delivery. The rail spur would most likely be built from the Union Pacific line, located approximately 50 miles (80 kilometers) east of the NTS. Impacts from construction and operation of the rail spur would be evaluated in detail if the site were selected for the SNF facility.

5.11.1.3 Transportation Impacts of Hazardous Chemicals. It is assumed that the

hazardous chemicals required and hazardous waste generated by the proposed SNF facility operation would be transported by truck. The onsite transportation impacts for these hazardous chemicals and wastes shipments are calculated based on the assumptions that they do not have any incident free impacts, the material would not leak during transport, only risk is due to traffic fatalities, and the material spill of entire contents is bound by the risk evaluated for the Expended Core Facility, considered under facility accidents.

The total distance for onsite shipment of these hazardous chemicals is assumed to be the maximum site boundary distance from the proposed SNF facility to the nearest highway. Based on the unit risk factor (Cashwell et. al. 1986), occupational and non-occupational fatalities considering a rural setting the onsite transportation risks are calculated, assuming 10 annual shipments.

The maximum one-way distance from the site to the NTS gate by which trucks would deliver hazardous wastes is 20 miles (32 kilometers). Based on 1.5 x 10-8 accident occupational fatalities per kilometer per shipment, 4.0 x 10-4 accident occupational fatalities are estimated over a 40-year period. Based on 5.3 x 10-8 accident non-occupational fatalities per kilometer per shipment 1.4 x 10-3 accident non-occupational fatalities are estimated over a 40-year period.

5.11.1.4 Transportation Impacts of Radioactive SNF. The definition of offsite

transportation include transportation of radioactive material from the shipping facility to the storage facility at the receiving site; therefore, local transportation does not separately address the onsite transportation impacts due to radioactive material shipment.

5.11.2 Regionalization Alternative

The impacts due to the Regionalization Alternative would be less than those described for the Centralization Alternative due to the smaller size of the facility and the smaller amount of waste expected.

5.12 Occupational and Public Health and Safety

The Waste Minimization and Pollution Prevention Awareness Plan at the NTS would be implemented within the SNF Management Program. While more chemicals per year would be used, health impacts to the public would continue to be minimal as a result of administrative and design controls to minimize releases of radioactive and chemical pollutants to the environment and to achieve compliance with permit requirements and applicable standards. Workers would continue to be protected from hazards specific to the workplace through appropriate training, protective equipment, monitoring, management controls, and occupational standards that would limit atmospheric and drinking water concentrations of potentially hazardous chemicals as well as limit radiation exposures. This would include protection from wastes generated from the increased use of the chemicals needed to accommodate spent fuel storage and from radioactivity associated with this storage. The NTS Emergency Preparedness Plan would continue to operate as designed to minimize or mitigate the impact of any emergency upon the health and safety of employees and the public.

Health effects from radiation are presented here as the risk of fatal cancer. This risk is in the ratio of their health risk estimator (risk of fatal cancer per rem of exposure). The value of this estimator for exposures to the public is 5.0 x 10-4 for fatal cancers. The corresponding estimator for exposures to workers is 4.0 x 10-4.

5.12.1 Centralization Alternative

This section evaluates the impacts to human health resulting from both contaminated air emissions and direct exposures associated with the proposed SNF facility under the Centralization Alternative. Pathways assessed include inhalation of air, ingestion of food, submersion in plumes, and direct exposure.

5.12.1.1 Radiological Doses. Releases of additional radionuclides to the environment

from operations at the proposed SNF facilities are summarized in Table 5.7-1. The annual committed doses to the public resulting from the proposed SNF facilities plus baseline operations in 1995 are provided in Table 5.7-3. The doses would be approximately 1 percent of the most restrictive health standard, and less than 0.1 percent of the natural background radiation. The dose to the maximally exposed member of the public is assumed to remain constant over the 40-year operational lifetime of the SNF; the population dose would increase slightly (less than 3 percent) due to population growth during this 40-year period.

Doses to SNF facility workers are assumed to be similar to those presently received by major DOE facility Waste Processing/Management personnel. Based on data for the years 1989 through 1991 for the Hanford Site, INEL and the Savannah River Site (SRS) (DOE 1992), it is estimated that the average dose to a worker from annual SNF operations at the NTS would be approximately 40 millirem and the maximum dose would be about 3,000 millirem. Assuming that 800 persons were involved at the peak of these operations, the total worker dose from annual SNF operations would be approximately 32 person-rem. Adding the baseline contribution, the total dose to all workers at the NTS would be about 36 person-rem.

5.12.1.2 Nonradiological Doses. Releases of additional nonradiological airborne

pollutants from operations at the proposed SNF facilities are summarized in Table 5.7-2. The concentrations from these releases have been calculated and are presented in Tables 5.7-4 and 5.7-5.

5.12.1.3 Radiological Health Effects. The fatal cancer risk to the most exposed member

of the public due to operation of the proposed SNF facilities would be 5.9 x 10-8. The fatal cancer risk to the most exposed member of the public due to operation of the proposed SNF facilities plus baseline operations (1995 levels) would be 6.5 x 10, over 40 years (estimated storage duration), the risk to this individual would be approximately 2.6 x 10-6. The estimated number of fatal cancers to the population within 80 kilometers (50 miles) of the proposed facility would be 4.4 x 10-5 for the operation of SNF facilities plus baseline operations and 4.1 x 10-5 for the operation of the SNF facilities without baseline operations. The number of increased fatal cancers from total NTS operations to the public during the estimate storage duration of the SNF would be approximately 1.8 x 10-3. The number of fatal cancers from all causes that would normally be expected to occur during this same time period to the 80-kilometer population is 1,500.

The calculation of the number of health effects to SNF workers from annual operations is based on somewhat lower risk estimators than for the general public. The estimators are lower as the result of different age distributions among workers and members of the public. The risks of fatal cancer to the average worker is estimated to be 1.6 x 10-5. The corresponding risk to the maximally exposed worker is estimated to be 1.2 x 10-3. An excess of 0.013 fatal cancer among all SNF facility workers is projected from peak annual operations. It is projected that exposures to radiation over the lifetime of SNF operations could result in an excess of 0.40 fatal cancer among these workers and an increased risk of 6.4 x 10-4 to an individual worker who is present over this time period. The risks and numbers of excess fatal cancers, both from annual and lifetime operations, would be increased by about 15 percent if the impacts to workers associated with baseline activities (Section 4.12.2.1) were included. The health effects due to radiological doses to a noninvolved worker, i.e., an NTS worker involved in activities other than SNF, would be on the order of 1 percent of the occupational exposure to an SNF worker, based on analyses for the SRS and INEL sites.

5.12.1.4 Nonradiological Health Effects. As indicated in Table 5.7-4, the concentrations

of all measured nonradiological pollutants at the NTS together with the inclusion of the Proposed Action would remain well within the health-based regulatory guidelines. The increases in pollutant concentrations from the Proposed Action would be negligible, compared to the existing baseline concentration; no adverse health effects from these pollutants would be anticipated.

The calculated maximum atmospheric concentrations of hazardous chemicals at the site boundary and onsite for the proposed action are presented in Table 5.7-5. The maximum concentrations at the site boundary are used to evaluate an exposure to a maximally exposed individual, whereas the maximum onsite concentrations could result in an exposure to a worker. Of the potential hazardous chemicals identified for the proposed action, cadmium, nickel and chromium VI (chrome) are carcinogens for which a total cancer risk was calculated. The remaining seven chemicals are noncarcinogens for which a hazard index was calculated. A hazard index value greater than 1 indicates a potential for adverse health effects.

Based on the maximum hazardous chemical concentrations at the site boundary, the lifetime fatal cancer risk and the hazard index to the maximally exposed member of the public would be only 5.4 x 10-13 and 2.5 x 10-3, respectively. Based on the maximum concentrations onsite, the lifetime fatal cancer risk and hazard index to a worker would be only 2.7 x 10-12 and 1.3 x 10-2, respectively. This indicates that there would be virtually no health impacts from nonradiological releases.

5.12.1.5 Industrial Safety. The measures of impacts for workplace hazards used in this

analysis are (1) total reportable injuries and illnesses and (2) non-exposure-related fatalities in the work place.

Based on hazard rates for personnel of DOE and its contractors, it is estimated that 270 injuries and illnesses would be reported and 0.48 fatality would occur from all SNF construction activities. It is further estimated that 807 injuries and illnesses would be reported and 0.81 fatality would occur among SNF workers during lifetime operations.

5.12.2 Regionalization Alternative

Under the Regionalization Alternative, the radiological and nonradiological doses from operation of the proposed SNF facilities at the NTS could generally be lower than those described under the centralization alternative. Any corresponding health effects may also decrease.

5.13 Utilities and Energy

Direct changes in utility demand as a result of the Centralization and Regionalization Alternatives were compared, depending on available data, against either projected 1995 demand or the peak usage for the years 1988 through 1992 for each utility resource. Since utility usage at NTS is projected to decrease, this comparison is conservative. Impacts to provision of a utility are considered to occur if the demand for a utility is equal to or exceeds the available capacity within the designated Region of Influence. For the purpose of analysis, the Region of Influence for each resource is defined as the area served by the utility provider responsible for meeting the service demands of the NTS.

5.13.1 Centralization Alternative

5.13.1.1 Water Consumption. For the Centralization Alternative, approximately

0.43 liter per second (6.85 gallons per minute) of water would be required to operate the modules within the facility (Harr 1994). The 14 active wells had a capacity of 387 liters per second (6,139 gallons per minute) in 1993 (DOE/NV 1993a). The SNF facilities would require 0.1 percent of this amount. NTS wells would operate at 35 percent of total capacity, when the 1989 peak water usage of 134 liters per second (2,125 gallons per minute) was combined with the SNF facility requirements.

The active wells at Area 5 have a capacity of 38 liters per second (595 gallons per minute) (DOE/NV 1994c). The SNF facilities under the Centralization Alternative would require 1 percent of this amount. Water usage in Area 5 would increase to approximately 33 percent of the pump yield if the 1993 water usage of 12 liters per second (191 gallons per minute) for Area 5 is combined with the SNF facility requirements under the Centralization Alternative.

5.13.1.2 Electrical Consumption. Under the Centralization Alternative, the SNF

facilities would require approximately 23,000 megawatt hours of electricity per year, or approximately 2.63 megavolt-amperes average demand (Harr 1994). The annual consumption of electricity of the SNF facilities would be approximately 12 percent of the 1995 annual consumption of electricity at NTS. The average electric demand of the SNF facilities would represent 6 to 7 percent of the projected 1995 peak electrical capacity of NTS. The average electric demand of the SNF facilities, combined with the peak electric demand of 39.5 megavolt-amperes, would utilize 94 to 105 percent of the transmission lines' current capacity.
The 2.63 megavolt-amperes required for the SNF facility represents approximately 61 percent of the operating capacity of the substation at Area 5. The energy requirements of the SNF facility under the Centralization Alternative combined with the 1993 electric demand on the Frenchman Flat substation would utilize 63 percent of the substation capacity. It might be necessary to construct additional transmission lines or another substation to support the SNF facilities.

5.13.1.3 Fuel Consumption. Energy requirements for the SNF facilities under the

Centralization Alternative were calculated assuming electrical power purchased from a utility was the primary source of energy; however, fossil fuels may be used to power backup generators and during construction activities. The amount of fuel that would be required for these operations would have little effect on fossil fuel usage at the NTS site.

5.13.1.4 Wastewater Disposal. Under the Centralization Alternative, approximately

0.43 liter per second (6.85 gallons per minute) of wastewater would be generated (Harr 1994). Currently, Area 5 has no wastewater facilities. A sewage treatment facility would need to be constructed for the SNF facilities under the Centralization Alternative.

5.13.2 Regionalization Alternative

The proposed SNF facilities under the Regionalization Alternative could consume less water, electricity, and fuel than under the Centralization Alternative. Less wastewater may also be generated; however, a sewage treatment facility would still need to be constructed.

5.14 Materials and Waste Management

Operation of the proposed SNF facilities would contribute transuranic, solid low-level, and sanitary waste as a consequence of transport, receipt, unloading, handling, and storage at the NTS. Under the SNF program, sources of potential contaminants would continue to be limited to construction support and site operation activities.

SNF storage activities would require the use of chemicals, and the majority of these would be expected to eventually become waste. Provisions would have to be made for the storage of the chemical raw materials used within the SNF complex as well as the waste material resulting from use. It was conservatively assumed that all chemical raw materials used by SNF would become hazardous wastes. Table 5.14-1 presents the estimated waste generation by waste classification for each of the two alternatives (Centralization and Regionalization) and by each of the two options (wet storage and dry storage).

5.14.1 Centralization Alternative

The Centralization Alternative would generate the greatest amount of waste from the SNF complex, since it is the alternative that contributes the larger amount of spent nuclear fuel to be stored. On an annual basis, the amount of waste generated by the SNF complex for this alternative would generally be greater than under the Regionalization Alternative. The handling capacity of the SNF complex is the factor that determines the amount of waste generation.

Table 5.14-1. Ten-year cumulative estimated waste generation for SNF alternatives at the NTS (m3).

Time Period	1995-2004	2005-2014	2015-2024	2025-2034
Centralization Alternative				
Wet Storage Option				
Transuranic waste	160	160	160	160
Low-level waste	1,950	1,950	1,950	1,950
Hazardous waste	7.4 x 101	7.4 x101	7.4 x 101	7.4 x 101
Sanitary waste	1.2 x 105	1.2 x 105	1.2 x 105	1.2 x 105
Dry Storage Option				
Low-level waste	76	76	76	76
Sanitary waste	1.9 x 104	1.9 x 104	1.9 x 104	1.9 x 104
Regionalization Alternative				
Wet Storage Option				
Transuranic waste	<160	<160	<160	<160
Low-level waste	<1,950	<1,950	<1,950	<1,950
Hazardous	<7.4 x 101	<7.4 x 101	<7.4 x 101	<7.4 x 101
Sanitary waste	<1.2 x 105	<1.2 x 105	<1.2 x 105	<1.2 x 105
Dry Storage Option				
Low-level waste	<76	<76	<76	<76
Sanitary waste	<1.9 x 104	<1.9 x 104	<1.9 x 104	<1.9 x 104

Source: Harr (1994).

5.14.1.1 Wet Storage Option.

5.14.1.1.1 Transuranic Waste-A small quantity (16 cubic meters, or 20.

9 cubic yards) of transuranic waste would be generated per year due to the recovery and purification of transuranic products from the wet storage option (Harr 1994). Placement of this waste into the transuranic waste storage cell would have minimal impact on the current transuranic waste management at the NTS.

5.14.1.1.2 Low-Level Waste-The wet storage option would contribute liquid low-

level waste as a result of its interim storage in water. This underwater storage would require filtered and deionized water to prevent possible corrosion problems with fuel elements and storage hardware; further waste would be generated from deionizer resin regeneration, filter backflushing, and chemical cleaning of the filter. An estimated 195 cubic meters (255 cubic yards) per year of low-level waste would be generated due to operation of the wet storage facility. Placement of this waste into the Radioactive Waste Management Site would be a viable option (see subsection 4.15.3). This quantity of low-level waste represents a minimal impact to the management of low-level waste at the NTS.

5.14.1.1.3 Hazardous Waste-Installation of the SNF complex would require

additional management of hazardous wastes, including the placement of satellite storage areas within the SNF complex and more frequent offsite shipments of hazardous waste. An evaluation of the impact that the additional hazardous wastes generated by the wet storage option would be conducted as part of the required National Environmental Policy Act evaluation.

Additional hazardous waste accumulated would be transferred to the Hazardous Waste Accumulation Site, collected, and removed to an offsite EPA-permitted treatment, storage, and disposal facility. The potential for hazardous waste to adversely affect the environment as a result of an accidental spill would be limited due to the great depth to groundwater and the arid climate, thereby minimizing the likelihood of migration of surface and shallow subsurface contamination. Similarly, any leaks from new underground or aboveground storage tanks would have limited potential to affect the environment (DOE/NV 1992c).

It is estimated that the wet storage option would generate approximately 7.4 cubic meters (9.7 cubic yards) of hazardous waste annually. This quantity of hazardous waste represents a minimal impact to the management of hazardous wastes at the NTS.

5.14.1.1.4 Sanitary Waste-The SNF wet storage option would generate

approximately 1.
2 x 104 cubic meters (15,696 cubic yards) of sanitary waste annually. This quantity of sanitary waste would double the current sanitary waste disposal quantity at the NTS. This would require construction of additional septic/leach field capacity and/or additional sewage lagoon capacity, creating the need for additional land area for sanitary waste disposal.

5.14.1.2 Dry Storage Option. Unless a hazardous material were added to the fuel at the

point of origination, hazardous material or mixed hazardous wastes would not be expected to be produced at a dry storage facility. With administrative controls applied at the storage facility to prevent hazardous material from coming in, the generation of mixed hazardous waste could be reduced or precluded. Any hazardous liquid and solid waste produced at the dry storage facility would be collected in a satellite accumulation area located inside the facility. Mixed waste would be stored onsite unless offsite storage and disposal facilities were licensed to accept radioactive waste.

Nonradioactive hazardous waste, such as oils, solvents, gloves, rags, and other materials associated with plant operation and maintenance, would be stored onsite until there were enough containers for shipment to an approved offsite treatment, storage, and disposal facility (Hale 1994).

5.14.1.2.1 Low-Level Waste-The low-level radioactive contaminated waste stream

would result mainly from wastes generated during the decontamination operations of the cask, crane, and contaminated areas, from disposed personal protective equipment and clothing that would be used and disposed of during decontamination operations, and from the filters and ion exchange resins used to decontaminate the decontamination liquids. This waste would be sent to the waste packaging unit, where it would be compacted into drums for disposal. Old cans and lids removed in the canning process would be collected and placed into solid waste containers (Hale 1994). Approximately 7.6 cubic meters (9.9 cubic yards) of low-level waste would be generated annually from the dry storage facility. This quantity of low-level waste represents a minimal impact to the management of low-level waste at the NTS.

5.14.1.2.2 Sanitary Waste-Sanitary sewage is the only liquid effluent to be

released from the facility.
The SNF dry storage option would generate approximately 1.9 x 103
cubic meters (2.5 x 103 cubic yards) of sanitary waste annually. This quantity of sanitary waste would double the current sanitary waste disposal quantity at the NTS. This would require construction of additional septic/leach field capacity and/or additional sewage lagoon capacity, creating the need for additional land area for sanitary waste disposal.

5.14.2 Regionalization Alternative

The Regionalization Alternative would generate less waste from the SNF facility than would the Centralization Alternative, since it would contribute the smaller amount of SNF to be stored. The handling capacity of the SNF complex determines the amount of waste generation. For either the wet storage option or dry storage option, the wastes generated would be less than those presented for the Centralization Alternative. Therefore, Table 5.14-1 presents the estimated waste generation for SNF for this alternative as less than that generated for the Centralization Alternative. The impacts presented for each of the waste categories for the Centralization Alternative apply to the Regionalization Alternative as well.

5.15 Facility Accidents

A potential exists for accidents at facilities associated with the handling, inspection, and storage of spent nuclear fuel at the NTS. Accidents can be categorized into events that are abnormal (for example, minor spills), events a facility was designed to withstand, and events a facility is not designed to withstand. These categories are termed abnormal, design basis, and beyond design basis accidents, respectively. Summarized here are consequences of possible facility
accidents for a member of the public at the nearest site boundary and at the nearest road, for the collective population within 80 kilometers (50 miles), for workers, and for the environment. See Section 5.11 for a summary of the assessment of transportation accidents.

A review of the historical record of accidents at the NTS is summarized in the following section. Methods used to assess potential future events are summarized in Section 5.15.2. Evaluations of accident impacts by alternative are summarized in Section 5.15.3 through 5.15.7. A summary comparison of accident impacts by alternative is given in Section 3.2. Additional supporting documentation for the accident impacts is given in a separate report (HNUS 1995).

This section examines the various activities that have been performed to assess the potential for accidents and their consequences for workers and the public for each alternative. A set of potential reasonably forseeable accidents over the 40-year period are described which envelop all accidents. Secondary impacts of accidents pertaining to cultural resources, economics, land use, endangered species, water resources, and ecology are also addressed. This section also covers emergency preparedness plans that have been established to mitigate the primary and secondary effects of accidents.

5.15.1 Historical SNF Accidents at NTS

There have been no SNF operations in the past several years at the NTS upon which to base an accident history.

5.15.2 Methodology

There are no facilities currently at the NTS for receiving, handling and storage of SNF that can be used as a basis for accident analysis. In the absence of suitable design details for the proposed SNF facilities during this stage of the SNF Management Program upon which to base
an accident analysis, the approach makes use of accident scenarios and associated data that have been analyzed and documented for similar facilities. They include spent nuclear fuel facilities at
INEL, the Hanford Site, SRS, and Naval sites.

5.15.2.1 Assumptions and Approach. A number of postulated accidents for similar

facilities have been selected to serve as a common basis for estimating accident consequences for workers and the public at the NTS. Although the accident scenarios, source terms, and related assumptions are similar to those for other sites, the estimated consequences are unique to the NTS because of site differences in modeling parameters pertaining to distances to site boundaries and population centers, population distributions, and meteorology. The GENII code (PNL 1988) was used to estimate accident consequences for the general public and for individuals onsite or at the site boundary, based on both 50 percent and 95 percent meteorology. Accident consequences and risk are described in terms of dose, latent cancer fatalities, and total health detriments for workers, for an individual at the site boundary, for a transient individual at the nearest public access, and for the public residing out to 80 kilometers (50 miles) from the proposed SNF facility. The estimated frequency of each selected accident is based on the reference source documentation.

The probability of an airplane crash into the facility is considered very small, because there are no nearby airports with large aircraft activity. For calculational purposes, the probability of such an accident is conservatively estimated at 10-6 per year. Potential accidents initiated by an airplane crash into the SNF facilities and the estimated consequences have been analyzed.

The secondary impacts of accidental releases of radioactive and hazardous materials are also addressed in a qualitative manner. Secondary impacts pertain to effects of accidents on land use, endangered species, water resources, cultural resources, and ecology.

5.15.2.2 Accident Screening. The potential accidents associated with existing SNF

facilities and operations were screened to determine which ones to include in the accident analysis for the NTS. The source documentation for this effort was primarily Appendices A, B, C, and D of Volume 1 that were selected by a screening process for existing SNF facilities. Initiating events were reviewed, including natural phenomena (e.g., earthquakes and tornadoes) and human-initiated events (e.g., human error, equipment failures, fires, explosives, plane crashes, and terrorism). Accidents associated with Expended Core Facility (ECF) operations at the NTS were analyzed separately, and the results are documented in Appendix D. For the NTS the maximum reasonably foreseeable criticality and nonradiological accidents are associated with the ECF. The potential for a criticality exists while the fuel is in dry storage, during handling, and in the wet storage pool. Although the probability of any criticality is very low, a hypothetical criticality of 1 x 1019 fissions was postulated in the ECF wet pool as a basis for estimating the maximum reasonably foreseeable consequences of a criticality.

The selected accidents include beyond-design-basis events in order to reflect the magnitude of accident consequences that envelop all other accidents having a reasonable probability of occurrence. They also include other accidents with lower consequences and typically higher probabilities of occurrence, to show a range of accident types and consequences. The accidents included in this set are reasonably foreseeable, meaning that there are one or more sequences of events that will lead to their occurrence, and the sequence with the highest probability of occurrence is greater than 1 x 10-7 per year. Accidents falling outside of this envelope, such as a meteorite impact, have been judged unreasonable because the probability of occurrence of less than 1 x 10-7 per year.

5.15.2.3 Accident Prevention and Mitigation. Under the Centralization and

Regionalization Alternatives, the proposed SNF facilities at the NTS will be of new design and construction and incorporate the latest technology for safety. The accidents postulated for the SNF facilities are based on operations and safety analyses that have been performed at similar facilities. One of the major design goals for the proposed SNF facilities is to achieve a reduced risk to facility personnel and to public health and safety relative to that associated with similar functions at existing SNF facilities. Significant improvements would exist between the design criteria and safety standards of the new SNF facilities and those for the current facilities, reducing total risk. These would include changes in design to current DOE structural and safety criteria and to planned throughput and storage capacity.

The SNF facilities would be designed to comply with current Federal, state, and local laws, DOE Orders, and industrial codes and standards. This would provide facilities that are highly resistant to the effects of severe natural phenomena, including earthquakes, floods, tornadoes, high winds, as well as credible events as appropriate to the site, such as fires and explosions, and man-made threats to its continuing structural integrity for containing materials.

An emergency preparedness plan will also be prepared to lower the potential consequences of an accident to workers and the public. All workers receive evacuation training to ensure timely and orderly personnel movement away from high-risk areas. Plans and arrangements with local authorities will also be inplace to evacuate the general public that may be at risk of exposure to hazardous materials that are accidently released.

5.15.3 No Action Alternative

There are currently no SNF operations at NTS. The No Action Alternative is not applicable for NTS.

5.15.4 Centralization Alternative

There is a potential for the accidental release of radioactive substances during various stages of SNF handling operations and storage. The operations begin with the receipt of an SNF shipment by truck or rail carrier followed by the unloading of the shipping cask from the transport vehicle. If the SNF requires cooling, the cask is placed into an unloading pool where the SNF is withdrawn from the cask, moved to a temporary wet storage basin, and placed into a fuel rack. Some SNF that does not require cooling will be handled in a special cell, where it will undergo canning and/or characterization. SNF that does not have to be cooled and does not require canning and/or characterization will be loaded into a dry storage canister within a transfer cask and transported to modular above-grade dry storage. Accidents that may occur during these handling operations and storage may involve the release of radioactive material to air or water pathways. The cause of accidents may be due to internal initiators, such as operator error, terrorism, and equipment failure or external initiators, such as an aircraft crash into a facility.

5.15.4.1 Radiological Impacts. The set of accidents described below have been chosen

to envelop the consequences of potential accidents for the proposed SNF facilities at the NTS. Although other accidents may occur, their estimated consequences are bounded by the accidents in the envelop or their probability of occurrence would be less than 1 x 10-6 per year. If such accidents were to occur, the dose and risk would be as shown in Tables 5.15-1 and 5.15-2 for 95 percent and 50 percent meteorology, respectively. Similarly, cancer fatalities are shown in Tables 5.15-3 and 5.15-4, and the health effects are shown in Tables 5.15-5 and 5.15-6.

5.15.4.1.1 Fuel Assembly Breach-Physical damage and breach of a fuel assembly

could accidentally occur from its being dropped, from objects falling on it, or from the fuel part being cut.
The fuel-cutting accident that has been postulated to occur at SRS SNF facilities is

Table 5.15-1. Summary of the Centralization Alternative accident analysis dose and risk estimates for the Nevada Test Site at 95 percent meteorology.

		95 Percent meteorology							
Accident scenario	Frequency (per year)	Dose				Risk			
		MEIa (rem)	NPAIb (rem)	Workerc (rem)	Population (person-rem)	MEI (rem/yr)	NPAI (rem/year)	Worker (rem/yr)	Population (person-rem/yr)
Fuel assembly breach	1.6 x 10-1 d	2.0 x 10-3	1.9 x 10-5	1.5 x 10-3	1.3 x 100	3.2 x 10-4	3.0 x 10-6	2.4 x 10-4	2.1 x 10-1
Dropped fuel cask	1.0 x 10-4 e	1.3 x 100	2.7 x 10-2	4.7 x 100	2.8 x 102	1.3 x 10-4	2.7 x 10-6	4.7 x 10-4	2.8 x 10-2
Severe impact and fire	1.0 x 10-6 f	9.3 x 100	9.9 x 10-2	3.5 x 100	5.8 x 103	9.3 x 10-6	9.9 x 10-8	3.5 x 10-6	5.8 x 10-3
Wind-driven missile impact	1.0 x 10-5	3.5 x 10-3	3.2 x 10-4	1.2 x 10-2	5.7 x 10-1	3.5 x 10-8	3.2 x 10-9	1.2 x 10-7	5.7 x 10-6

into dry storage									
Airplane crash into dry storage	1.0 x 10-6 [f]	1.5 x 100	7.7 x 10-2	1.2 x 101	5.6 x 102	1.5 x 10-6	7.7 x 10-8	1.2 x 10-5	5.6 x 10-4
Airplane crash into dry cell facility	1.0 x 10-6 [f]	1.2 x 101	2.4 x 10-1	2.3 x 101	7.0 x 103	1.2 x 10-5	2.4 x 10-7	2.3 x 10-5	7.0 x 10-3
Airplane crash into water pool	1.0 x 10-6 [f]	2.2 x 10-2	1.4 x 10-4	2.4 x 10-2	5.8 x 101	2.2 x 10-8	1.4 x 10-10	2.4 x 10-8	5.8 x 10-5

a. Maximum exposed individual (MEI). Dose received from inhalation, external, and ingestion pathways.

b. Nearest public access individual (NPAI). Dose received from inhalation and external pathways.

c. Dose received from inhalation and external pathways.

d. The value is <1.6 x 10-1. For calculational purposes, the value is assumed to be 1.6 x 10-1.

e. The value is <1.0 x 10-4. For calculational purposes, the value is assumed to be 1.0 x 10-4.

f. The value is <1.0 x 10-6. For calculational purposes, the value is assumed to be 1.0 x 10-6.

Table 5.15-2. Summary of the Centralization Alternative accident analysis dose and risk estimates for the Nevada Test Site at 50 percent meteorology.

		50 Percent meteorology							
Accident scenario	Frequency (per year)	Dose				Risk			
		MEI[a] (rem)	NPAI[b] (rem)	Worker[c] (rem)	Population[d] (person-rem)	MEI (rem/yr)	NPAI (rem/year)	Worker (rem/yr)	Population (person-rem/yr)
Fuel assembly breach	1.6 x 10-1 [e]	5.0 x 10-5	2.9 x 10-7	4.7 x 10-5	3.4 x 10-2	8.0 x 10-6	4.6 x 10-8	7.5 x 10-6	5.4 x 10-3
Dropped fuel cask	1.0 x 10-4 [f]	3.2 x 10-2	4.1 x 10-4	1.5 x 10-1	6.9 x 100	3.2 x 10-6	4.1 x 10-8	1.5 x 10-5	6.9 x 10-4
Severe impact and fire	1.0 x 10-6 [g]	2.3 x 10-1	1.5 x 10-3	1.1 x 10-1	1.4 x 102	2.3 x 10-7	1.5 x 10-9	1.1 x 10-7	1.4 x 10-4
Wind-driven missile into dry storage area	1.0 x 10-5	8.7 x 10-5	4.7 x 10-6	3.7 x 10-4	1.3 x 10-2	8.7 x 10-10	4.7 x 10-11	3.7 x 10-9	1.3 x 10-7
Airplane crash into dry storage	1.0 x 10-6 [g]	3.7 x 10-2	1.2 x 10-3	3.9 x 10-1	1.4 x 101	3.7 x 10-8	1.2 x 10-9	3.9 x 10-7	1.4 x 10-5
Airplane crash into dry cell facility	1.0 x 10-6 [g]	3.1 x 10-1	3.7 x 10-3	7.4 x 10-1	1.7 x 102	3.1 x 10-7	3.7 x 10-9	7.4 x 10-7	1.7 x 10-4
Airplane crash into water pool	1.0 x 10-6 [g]	5.6 x 10-4	2.0 x 10-6	7.4 x 10-4	1.4 x 100	5.6 x 10-10	2.0 x 10-12	7.4 x 10-10	1.4 x 10-6

a. Maximum exposed individual (MEI). Dose received from inhalation, external, and ingestion pathways.

b. Nearest public access individual (NPAI). Dose received from inhalation and external pathways.

c. Dose received from inhalation and external pathways.

d. Dose received from inhalation, external, and ingestion pathways.

e. The value is <1.6 x 10-1. For calculational purposes, the value is assumed to be 1.6 x 10-1.

f. The value is <1.0 x 10-4. For calculational purposes, the value is assumed to be 1.0 x 10-4.

g. The value is <1.0 x 10-6. For calculational purposes, the value is assumed to be 1.0 x 10-6.

Table 5.15-3. Summary of the Centralization Alternative accident analysis cancer fatality and risk estimates for the Nevada Test Site at 95 percent meteorology.

		95 Percent meteorology							
Accident scenario	Frequency (per year)	Cancer fatalities				Cancer fatality risk (cancer fatalities/yr)			
		MEIa	NPAIb	Workerc	Populationd	MEI	NPAI	Worker	Population
Fuel assembly breach	1.6 x 10-1 e	9.8 x 10-7	9.3 x 10-9	6.0 x 10-7	6.6 x 10-4	1.6 x 10-7	1.5 x 10-9	9.6 x 10-8	1.1 x 10-4
Dropped fuel cask	1.0 x 10-4 f	6.4 x 10-4	1.4 x 10-5	1.9 x 10-3	2.8 x 10-1	6.4 x 10-8	1.4 x 10-9	1.9 x 10-7	2.8 x 10-5
Severe impact and fire	1.0 x 10-6 g	4.7 x 10-3	5.0 x 10-5	1.4 x 10-3	5.8 x 100	4.7 x 10-9	5.0 x 10-11	1.4 x 10-9	5.8 x 10-6
Wind-driven missile impact into dry storage	1.0 x 10-5	1.7 x 10-6	1.6 x 10-7	4.9 x 10-6	2.9 x 10-4	1.7 x 10-11	1.6 x 10-12	4.9 x 10-11	2.9 x 10-9
Airplane crash into dry storage	1.0 x 10-6 g	7.4 x 10-4	3.9 x 10-5	4.8 x 10-3	5.6 x 10-1	7.4 x 10-10	3.9 x 10-11	4.8 x 10-9	5.6 x 10-7
Airplane crash into dry cell facility	1.0 x 10-6 g	6.1 x 10-3	1.2 x 10-4	1.8 x 10-2	7.0 x 100	6.1 x 10-9	1.2 x 10-10	1.8 x 10-8	7.0 x 10-6
Airplane crash into water pool	1.0 x 10-6 g	1.1 x 10-5	7.1 x 10-8	9.6 x 10-6	5.8 x 10-2	1.1 x 10-11	7.1 x 10-14	9.6 x 10-12	5.8 x 10-8

a. Maximum exposed individual (MEI). Radiation exposure received from inhalation, external, and ingestion pathways.

b. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

c. Radiation exposure received from inhalation and external pathways.

d. Radiation exposure received from inhalation, external, and ingestion pathways.

e. The value is <1.6 x 10-1. For calculational purposes, the value is assumed to be 1.6 x 10-1.

f. The value is <1.0 x 10-4. For calculational purposes, the value is assumed to be 1.0 x 10-4.

g. The value is <1.0 x 10-6. For calculational purposes, the value is assumed to be 1.0 x 10-6.

Table 5.15-4. Summary of the Centralization Alternative accident analysis cancer fatality and risk estimates for the Nevada Test Site at 50 percent meteorology.

		50 Pecent meteorology							
Accident scenario	Frequency (per year)	Cancer fatalities				Cancer fatality risk (cancer fatalities/yr)			
		MEIa	NPAIb	Workerc	Populationd	MEI	NPAI	Worker	Population
Fuel assembly	1.6 x 10-1 e	2.5 x 10-8	1.4 x 10-10	1.9 x 10-8	1.7 x 10-5				

breach						4.0 x 10-9	2.2 x 10-11	3.0 x 10-9	2.7 x 10-6
Dropped fuel cask	1.0 x 10-4 f	1.6 x 10-5	2.1 x 10-7	6.0 x 10-5	3.5 x 10-3	1.6 x 10-9	2.1 x 10-11	6.0 x 10-9	3.5 x 10-7
Severe impact and fire	1.0 x 10-6 g	1.2 x 10-4	7.5 x 10-7	4.5 x 10-5	1.4 x 10-1	1.2 x 10-10	7.5 x 10-13	4.5 x 10-11	1.4 x 10-7
Wind-driven missile impact into dry storage	1.0 x 10-5	4.4 x 10-8	2.4 x 10-9	1.5 x 10-7	6.7 x 10-6	4.4 x 10-13	2.4 x 10-14	1.5 x 10-12	6.7 x 10-11
Airplane crash into dry storage	1.0 x 10-6 g	1.8 x 10-5	6.0 x 10-7	1.6 x 10-4	6.8 x 10-3	1.8 x 10-11	6.0 x 10-13	1.6 x 10-10	6.8 x 10-9
Airplane crash into dry cell facility	1.0 x 10-6 g	1.5 x 10-4	1.9 x 10-6	3.0 x 10-4	1.7 x 10-1	1.5 x 10-10	1.9 x 10-12	3.0 x 10-10	1.7 x 10-7
Airplane crash into water pool	1.0 x 10-6 g	2.8 x 10-7	1.0 x 10-9	3.0 x 10-7	7.0 x 10-4	2.8 x 10-13	1.0 x 10-15	3.0 x 10-13	7.0 x 10-10

a. Maximum exposed individual (MEI). Radiation exposure received from inhalation, external, and ingestion pathways.

b. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

c. Radiation exposure received from inhalation and external pathways.

d. Radiation exposure received from inhalation, external, and ingestion pathways.

e. The value is <1.6 x 10-1. For calculational purposes, the value is assumed to be 1.6 x 10-1.

f. The value is <1.0 x 10-4. For calculational purposes, the value is assumed to be 1.0 x 10-4.

g. The value is <1.0 x 10-6. For calculational purposes, the value is assumed to be 1.0 x 10-6.

Table 5.15-5. Summary of the Centralization Alternative accident analysis health effects and risk estimates for the Nevada Test Site at 95 percent meteorology.

		95 Percent meteorology							
Accident scenario	Frequency (per year)	Total health detrimentsa				Total health detriment risk (detriments/yr)			
		MEIb	NPAIc	Workerd	Populatione	MEI	NPAI	Worker	Population
Fuel assembly breach	1.6 x 10-1 f	1.4 x 10-6	2.1 x 10-10	8.4 x 10-7	9.7 x 10-4	2.2 x 10-7	3.4 x 10-11	1.3 x 10-7	1.6 x 10-4
Dropped fuel cask	1.0 x 10-4 g	9.3 x 10-4	3.0 x 10-7	2.6 x 10-3	4.1 x 10-1	9.3 x 10-8	3.0 x 10-11	2.6 x 10-7	4.1 x 10-5
Severe impact and fire	1.0 x 10-6 h	6.8 x 10-3	1.1 x 10-6	2.0 x 10-3	8.5 x 100	6.8 x 10-9	1.1 x 10-12	2.0 x 10-9	8.5 x 10-6
Wind-driven missile impact into dry storage	1.0 x 10-5	2.5 x 10-6	3.4 x 10-9	6.9 x 10-6	4.2 x 10-4	2.5 x 10-11	3.4 x 10-14	6.9 x 10-11	4.2 x 10-9
Airplane crash into dry st	1.0 x 10-6 h	1.1 x 10-3	8.8 x 10-7	6.7 x 10-3	8.2 x 10-1	1.1 x 10-9	8.8 x 10-13	6.7 x 10-9	8.2 x 10-7
Airplane crash into dry ce facility	1.0 x 10-6 h	8.9 x 10-3	2.7 x 10-6	2.6 x 10-2	1.0 x 101	8.9 x 10-9	2.7 x 10-12	2.6 x 10-8	1.0 x 10-5
Airplane crash into water	1.0 x 10-6 h	1.6 x 10-5	1.5 x 10-9	1.3 x 10-5	8.5 x 10-2	1.6 x 10-11	1.5 x 10-15	1.3 x 10-11	8.5 x 10-8

a. Maximum exposed individual (MEI). The estimated number of cancer fatalities, cancer non fatalities, and genetic defects resulting from the radiation exposure.

b. Radiation exposure received from inhalation, external, and ingestion pathways.

c. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

d. Radiation exposure received from inhalation and external pathways.

e. Radiation exposure received from inhalation, external, and ingestion pathways.

f. The value is <1.6 x 10-1. For calculational purposes, the value is assumed to be 1.6 x 10-1.

g. The value is <1.0 x 10-4. For calculational purposes, the value is assumed to be 1.0 x 10-4.

h. The value is <1.0 x 10-6. For calculational purposes, the value is assumed to be 1.0 x 10-6.

Table 5.15-6. Summary of the Centralization Alternative accident analysis health effects and risk estimates for the Nevada Test Site at 50 percent meteorology.

		50 Percent meteorology							
		Total health detrimentsa				Total health detriment risk (detriments/yr)			
Accident scenario	Frequency (per year)	MEIb	NPAIc	Workerd	Populatione	MEI	NPAI	Worker	Population
Fuel assembly breac	1.6 x 10-1 f	3.7 x 10-8	1.4 x 10-8	2.6 x 10-8	2.5 x 10-5	5.9 x 10-9	2.2 x 10-9	4.2 x 10-9	4.0 x 10-6
Dropped fuel cask	1.0 x 10-4 g	2.3 x 10-5	2.0 x 10-5	8.4 x 10-5	5.1 x 10-3	2.3 x 10-9	2.0 x 10-9	8.4 x 10-9	5.1 x 10-7
Severe impact and f	1.0 x 10-6 h	1.7 x 10-4	7.2 x 10-5	6.2 x 10-5	2.1 x 10-1	1.7 x 10-10	7.2 x 10-11	6.2 x 10-11	2.1 x 10-7
Wind-driven missile impact into dry storage	1.0 x 10-5	6.4 x 10-8	2.3 x 10-7	2.1 x 10-7	9.7 x 10-6	6.4 x 10-13	2.3 x 10-12	2.1 x 10-12	9.7 x 10-11
Airplane crash into dry storage	1.0 x 10-6 h	2.7 x 10-5	5.6 x 10-5	2.2 x 10-4	9.9 x 10-3	2.7 x 10-11	5.6 x 10-11	2.2 x 10-10	9.9 x 10-9
Airplane crash into dry cell facility	1.0 x 10-6 h	2.2 x 10-4	1.8 x 10-4	4.2 x 10-4	2.5 x 10-1	2.2 x 10-10	1.8 x 10-10	4.2 x 10-10	2.5 x 10-7
Airplane crash into water pool	1.0 x 10-6 h	4.1 x 10-7	1.0 x 10-7	4.1 x 10-7	1.0 x 10-3	4.1 x 10-13	1.0 x 10-13	4.1 x 10-13	1.0 x 10-9

a. Maximum exposed individual (MEI). The estimated number of cancer fatalities, cancer non fatalities, and genetic defects resulting from the radiation exposure.

b. Radiation exposure received from inhalation, external, and ingestion pathways.

c. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

d. Radiation exposure received from inhalation and external pathways.

e. Radiation exposure received from inhalation, external, and ingestion pathways.

f. The value is <1.6 x 10-1. For calculational purposes, the value is assumed to be 1.6 x 10-1.

g. The value is <1.0 x 10-4. For calculational purposes, the value is assumed to be 1.0 x 10-4.

h. The value is <1.0 x 10-6. For calculational purposes, the value is assumed to be 1.0 x 10-6.

chosen as representative of the fuel assembly breach accident (E. I. du Pont de Nemours & Co. 1983). During normal SRS operations, the inert, non-uranium-containing extremities of some SNF elements are cut off in the repackaging basin before the elements are bundled. The accident occurs when the actual uranium fuel is inadvertently cut, causing a radioactive release.

The source term for this accident is shown in Table 5.15-7. The estimated frequency of occurrence for this accident is 1.6 x 10-1 per year, based on SRS operating experience with SNF. Because of anticipated differences in operations and facilities at the NTS, however, the actual frequency is expected to be much less than 1.6 x 10-1 per year.

5.15.4.1.2 Dropped Fuel Cask-The dropped fuel cask accident that has been

postulated to occur at the Hanford Site (reference Volume 1, Appendix A) is chosen as representative of the dropped fuel cask/fuel handling accident for the new Centralization Alternative facility at NTS.
This accident is initiated when a fuel cask is dropped and overturned in the fuel transfer area. Broken fuel elements spill out of the cask, within the pool building but away from the pool. It is assumed that the shipping cask ruptures, exposing all of the broken fuel elements in three canisters: 42 fuel elements, each containing 22.5 kilograms (50 pounds) of fuel. The source term for this accident is shown in Table 5.15-8. The probability of this accident is estimated to be less than 1 x 10-4 per year.

5.15.4.1.3 Severe Impact and Fire-The severe impact and fire accident that has

been postulated to occur at the Hanford Site (reference Volume 1, Appendix A) is chosen as representative of the severe impact and fire/onsite transportation accident for the new Centralization Alternative facility at NTS.
This accident assumes an unspecified initiating event that subjects the fuel assemblies to a severe impact, breach of the transport cask, and a fire. During the accident, the fuel pins rupture on impact or upon heating in the fire, which burns for an hour before being extinguished. Volatiles, particulates, and noble gases are released to the atmosphere. The source term for a release of 540 curies is shown in Table 5.15-9. The estimated probability of occurrence for this accident, reflecting the fact that the facilities of this site would be new, is less than 1 x 10-6 per year.

5.15.4.1.4 Wind-driven Missile Impact into Storage Casks-The wind-driven

missile impact into storage casks accident that has been postulated to occur at the Naval Reactors Site (reference Volume 1, Appendix D) is chosen as representative of the wind-driven

Table 5.**15-7.** Estimated radionuclide releases for a fuel assembly breach accident at the NTS.

Radionuclide	Release (Ci)
Iodine-131	7.1 x 10-2
Iodine-133	1.4 x 10-30
Krypton-85	1.8 x 102
Xenon-133m	1.1 x 10-8
Xenon-133	1.1 x 100

a. Source: E. I. du Pont de Nemours & Co. (1983).

Table 5.15-8. Estimated radionuclide releases for a dropped fuel cask accident at the NTS.

Radionuclide	Release (Ci)	
	Onsite (2 hours)	Offiste (8 hours)
Plutonium-236	1.3 x 10-8	5.4 x 10-8
Plutonium-238	2.9 x 10-3	1.2 x 10-2
Plutonium-239	6.7 x 10-3	2.7 x 10-2
Plutonium-240	3.5 x 10-3	1.4 x 10-2
Plutonium-241	2.7 x 10-1	1.1 x 100
Plutonium-242	1.3 x 10-6	5.1 x 10-6
Americium-241	5.7 x 10-3	2.3 x 10-2
Curium-244	2.8 x 10-4	1.1 x 10-3
Europium-154	5.4 x 10-3	2.1 x 10-2
Cesium-134	7.9 x 10-3	3.2 x 10-2
Cesium-137	4.5 x 10-1	1.8 x 100
Cerium-144	1.7 x 10-3	6.8 x 10-3
Praseodymium-144	1.7 x 10-3	6.8 x 10-3
Praseodymium-144m	2.0 x 10-5	8.1 x 10-5
Promethium-147	1.2 x 10-1	4.9 x 10-1
Antimony-125	7.3 x 10-3	2.9 x 10-2

Tellurium-125m	1.8 x 10-3	7.3 x 10-3
Ruthenium-106	3.2 x 10-3	1.3 x 10-2
Strontium-90	3.5 x 10-1	1.4 x 100
Yttrium-90	3.5 x 10-1	1.4 x 100

a. Source: Volume 1, Appendix A, Table A-1.

Table 5.15-9. Estimated radionuclide releases for a severe impact and fire accident at the NTS.

Radionuclide	Release (Ci)
Tritium	4.6 x 101
Krypton-85	4.0 x 102
Strontium-90	2.7 x 10-2
Ruthenium-106	1.3 x 100
Cesium-134	1.7 x 101
Cesium-137	8.0 x 101
Plutonium-238	8.9 x 10-4
Plutonium-239	1.6 x 10-3
Plutonium-240	1.8 x 10-3
Plutonium-241	7.3 x 10-2
Americium-241	1.0 x 10-3

a. Source: Volume 1, Appendix A, Table A-14.

missile accident for the new Centralization Alternative facility at NTS. This accident is initiated by natural phenomena, a major wind storm or tornado in excess of facility design basis. In this scenario, a large object is propelled by the wind into a storage container, causing the container seal to be breached. No fuel damage results from the impact because of the strength of the containers used. The source term is based on the spent nuclear fuel corrosion film. One percent of the original corrosion film on the fuel is released from the cask to the atmosphere. The source term is shown in Table 5.15-10. The probability of this event is estimated to be less than 1 x 10-5 per year, based on a design basis tornado probability of 1 x 10-3 per year and a missile impact with damage probability of less than 1 x 10-2.

5.15.4.1.5 Airplane Crash Into Dry Storage-The airplane crash into dry storage

accident that has been postulated to occur at the Naval Reactors Site (reference Volume 1, Appendix D) is chosen as representative of the airplane crash into the dry storage area accident for the new Centralization Alternative facility at NTS. This accident initiated by an airplane crash into the SNF dry storage facility. The accident is postulated to cause damage to a single storage cask. Due to the severity of the impact, the cask seal is assumed to be breached, resulting in damage to the fuel and the release of corrosion products, located on the SNF exterior, to the environment. The impact also causes a fire and a release of fission products. It is assumed that 1 percent of all of the fuel units stored inside the cask are damaged either by the impact or by the fire, and that those fission products are available for release. Of the available fission products, 100 percent of the noble gases, 3 percent of the halogens, 1.1 percent of the cesium, and 0.1 percent of the remaining solids are released to the environment. Also, 10 percent of the original corrosion products from the fuel units are released from the cask to the atmosphere. The source term for this accident is shown in Table 5.15-11. The probability of this accident is small and is assumed to be less than 1 x 10-6 per year.

5.15.4.1.6 Airplane Crash into Dry Cell Facility-The airplane crash into the dry

cell facility accident that has been postulated to occur at the naval Reactors Site (reference Volume 1, Appendix D) is chosen as representative of the airplane crash into the canning and characterization cell accident for the new Centralization Alternative facility at NTS. This accident is initiated by an airplane crash into the dry cell facility. The accident is postulated to cause significant damage to the building, resulting in the loss of containment and filtered exhaust

Table 5.15-10. Estimated radionuclide releases for a wind-driven missile impact into a storage cask at the NTS.

Radionuclide	Release (Ci)
Cobalt-60	9.58 x 10-2
Iron-55	1.76 x 10-1
Cobalt-58	3.54 x 10-2
Manganese-54	5.98 x 10-3
Iron-59	5.11 x 10-4

a. Source: Volume 1, Appendix D, Section F.1.4.2.2.1.

Table 5.15-11. Estimated radionuclide releases for an airplane crash into dry storage facility at the NTS.

Radionuclide	Release (Ci)
Cesium-134	2.6 x 101
Cesium-137	3.6 x 101
Plutonium-238	5.9 x 10-2
Barium-137m	3.1 x 100
Strontium-90	3.1 x 100
Cerium-144	7.2 x 100
Niobium-95	4.4 x 100
Yttrium-90	3.1 x 100
Ruthenium-106	6.1 x 10-1

a. Source: Volume 1, Appendix D, Section F.1.4.2.2.2.

systems. The fuel units inside the dry cell are damaged by the impacts and fire. The impact also results in the release of corrosion products to the environment. For this accident scenario, 1 percent of the fuel units stored inside the dry cell are assumed to be damaged by either the impact or the resultant fire and those fission products would be available for release. Of the fission products available for release, 100 percent of the noble gases, 3 percent of the halogens, 1.1 percent of the cesium, and 0.1 percent of the remaining solids are released to the environment. Ten percent of the available corrosion products are released to the environment. The source term for this accident is shown in Table 5.15-12. The probability of this accident is estimated to be less than 1 x 10-6 per year.

5.15.4.1.7 Airplane Crash into Water Pool-The airplane crash into the SNF water

pool accident that has been postulated to occur at the Naval Reactors Site (reference Volume 1, Appendix D) is chosen as representative of the airplane crash into the SNF water pool accident for the new Centralization Alternative facility at NTS. This externally initiated accident occurs when an airplane crashes into an SNF water pool and damages the fuel units stored there. Fission products and corrosion products are released from the fuel units into the water pool, but the pool water is not released to the environment. The presence of the pool water results in only a release of gaseous fission products to the atmosphere. In this accident scenario 1 percent of all the fuel units stored inside the pool are postulated to be damaged and those fission products are available for release. Of the available fission products, 100 percent of the noble gases and 25 percent of the halogens are released to the pool water. Due to the presence of pool water, there is a reduction of the halogen release by a factor of 10 prior to release to the atmosphere. The source term for this accident is shown in Table 5.15-13. The probability of this accident is estimated to be less than 1 x 10-6 per year.

5.15.4.2 Nonradiological Hazards. The two bounding accidents involving nonradiological

hazards are a chemical spill and fire and a diesel fuel fire. Both of these accidents are associated with the Expended Core Facility operations and the accident frequencies and impacts are addressed in Volume 1, Appendix D. The analyses of these accidents considered the impacts to workers on the site as well as to the offsite population. The impacts were measured in terms of potential heath effects due to exposure to toxic chemicals released during these accidents. Since the ECF at this site will be a new design and construction, it will incorporate all applicable

Table 5.15-12. Estimated radionuclide releases for an airplane crash into dry facility at the NTS Table 5.15-13. Estimated radionuclide releases for an airplane crach into an SNF water pool at the NTS

standards and regulations and therefore limit the potential exposures to the workers and the public in the event of an accident.

5.15.4.3 Secondary Impacts. In the event of an accidental release of radioactive

substances, there is a potential for secondary impacts to cultural resources, endangered species, water resources, and public and agricultural land use, the ecology in the vicinity of the accident, national defense, and local economics. In order to assess the impacts, a severe accident and the resulting release of radioactive material were evaluated. The accident chosen for evaluation was an airplane crash into the Centralization Alternative canning and characterization (dry) cell. Utilizing the 50 percent meteorology and the typical flat topography of the proposed SNF site, the dispersion of radioactive material and the resulting dose were calculated. Figure 5.15-1 shows the isodose lines ranging from 870 millirem per year down to 87 millirem per year, which is approximately equivalent to cosmic and terrestrial background radiation. The farthest distance between the accident site and the 87 millirem per year line is 8,000 feet (2,400 meters). Therefore, in order to minimize the potential impact of an accident on the non-NTS personnel and the public, the SNF facility should be located at least 8,000 feet (2,400 meters) from the NTS boundary. Given the available space within Area 5 and the large buffer zone surrounding the proposed SNF site and the NTS, the final siting location could easily accommodate this design constraint. This design constraint could be applied to other environmental resources during the final siting process. The secondary impacts in other environmental resources which would not be accommodated as easily are summarized below. Table 5.15-14 presents a summary of the postulated severe accident secondary impacts on the environment, economy, and national defense. The evaluation was performed using 50 percent meteorology.

5.15.5 Decentralization Alternative

The Decentralization Alternative is not applicable for the NTS.

5.15.6 1992/1993 Planning and Basis Alternative

There are currently no SNF operations at NTS. The 1992/1993 Planning Basis Alternative is not applicable for NTS.

Figure 5.15-1. Typical Isodose lines for an airplane crash into a dry cell accident with 50 percent meteorology for northeastern Area 5 of the NTS.

Table 5.15-14. Secondary impacts of the Centralized Alternative accidents at NTS.

Environmental or social factor	Impact
Land Use	Possible minor impact. The dispersion of radioactive material would be limited within the NTS boundaries. The major NTS facilities in the vicinity of the proposed SNF site include the Radioactive Waste Management Site and the Liquified Gaseous Fuels Spill Test Facility.
Cultural Resource	Possible minor impact. Surveys conducted for other Area 5 activities have indicated only scattered artifacts in the vicinity of the proposed SNF site. No major prehistoric/historic sites are anticipated to be located in the vicinity of the proposed SNF site. Access to any random artifacts found during the accident investigation and cleanup would have to be restricted until radioactive decay had occurred.
Aesthetic and Scenic Resources	No impact. The area of contamination does not envelop aesthetic and scenic resources.
Water Resources	No impact. The nuclear testing program has dispersed radioactive material in the vicinity of the proposed SNF site during aboveground nuclear tests. Due to the great depths of the groundwater, the groundwater was not contaminated. It is anticipated that an accident would not alter the pathways to the groundwater.
Ecological Resources	Possible impact. Many threatened or endangered plants and animals, except fish species, are potentially on or near the NTS.
Treaty Rights	No impact. There are no onsite areas subject to Native American Treaty rights.
National Defense	No impact. The area of contamination does not envelop U.S. military or defense industry facilities.
Economic Impacts	Possible minor impact. The dispersion of radioactive material would be limited within the NTS boundaries. The major NTS facilities in the vicinity of the proposed SNF site include the Radioactive Waste Management Site and the Liquified Gaseous Fuels Spill Test Facility.

5.15.7 Regionalization Alternative

Under the Regionalization Alternative, new facilities would be constructed and operated for SNF. Details for the new facilities have not been defined, but it is reasonable to expect that they would be similar to but with less throughput and storage requirements than those needed for the

Centralization Alternative. Due to smaller throughput and storage requirements, the potential for accidents (i.e., probability of occurrence) will be similar to but less than those described for the Centralization Alternative. The accident consequences would be similar for both alternatives.
Consequently, it is reasonable to assume the accident consequences and risks described for the Centralization Alternative envelop the Regionalization Alternative.

5.15.8 Emergency Preparedness and Plans

DOE has issued a series of Orders specifying the requirements for emergency preparedness (DOE Orders 5500.1A, 5500.2A, 5500.3, draft 5500.3A, 5500.4, and 5500.9), and each DOE site has established an emergency management program. These programs are developed and maintained to ensure adequate response for most accident conditions and to provide the framework to readily extend response efforts for accidents not specifically considered. The emergency management program incorporates activities associated with planning, preparedness, and response.

Officials at each DOE site have specified the emergency preparedness requirements for the DOE facilities under their jurisdiction in a manner consistent with the relevant DOE Orders. All existing facilities have emergency plans and procedures that either implement the DOE and site requirements or are integrated with the site planning.

The Nevada Operations Office Emergency Preparedness Plan is designed to minimize or mitigate the impact of any emergency upon the health and safety of employees and the public. The plan integrates all emergency planning into a single entity to minimize overlap and duplication, and to ensure proper responses to emergencies not covered by a plan or directive. The plan is based upon the concept that the Manager, Nevada Operations Office, has the capability to manage, counter, and recover from an emergency occurring within the Nevada Operations Office responsibility.

The Nevada Operations Office plan provides for (1) identification and notification of personnel for any emergency that may develop during operational or nonoperational hours; (2) the receipt of warnings, weather advisories, or any other information that may provide advance warning of a possible emergency; and (3) prearranged actions which may be taken to minimize the effect of the emergency. The plan is based upon current Nevada Operations Office vulnerability assessments, resources, and capabilities regarding emergency preparedness.

5.16 Cumulative Impacts and Impacts from Connected or Similar Actions

The NTS already contains several major DOE and non-DOE facilities, unrelated to SNF, that would continue to operate throughout the operating life of the proposed SNF management facilities. The activities associated with these existing facilities produce environmental consequences that have been included in the baseline environmental conditions (Chapter 4) against which Sections 5.1 through 5.15 have assessed the environmental consequences of the Centralization and Regionalization Alternatives. This section uses the environmental baseline conditions presented in Chapter 4 to assess potential cumulative impacts from the proposed SNF management facilities, if constructed at the NTS, plus other reasonably forseeable activities.

In addition to the proposed SNF management facilities, reasonably foreseeable activities considered in this cumulative impact assessment include the proposed Expended Core Facility (described in Volume 1, Appendix D), activities included in the present Five-Year Plan and Master Plan for the NTS (DOE/NV 1993b), and the potential geologic repository at the Yucca Mountain site. Major programmatic initiatives consist of constructing the following: facilities and site improvements for a new consolidated testing area sponsored by Los Alamos and Lawrence Livermore National Laboratories; a Transuranic Waste Certification Building; refurbishment or expansion of several existing facilities; construction of several small office buildings; several site assessment and remediation projects; several roadway upgrading or improvement projects; several flood control projects; and several utility installation or upgrade projects. In addition, a number of communications, security, an safety improvements identified in the Master Plan are under consideration throughout the NTS.

Specifically with respect to Area 5, a number of projects are proposed (DOE/NV 1993b). Continued use of the Radioactive Waste Management Site and the Spill Test Facility is proposed. Providing storage for transuranic waste and hazardous waste prior to offsite disposal is also proposed. Additional projects have also been proposed to provide utility and infrastructure upgrades and improvements. These projects include replacing the Frenchman Flat power substation and a number of construction projects for water Service Area C including connecting the Yucca Flat and Frenchman Flat water systems, and adding additional tanks and water lines in the area. Nearby proposals identified for Area 6 include following a formal, expansion-oriented land-use plan for the Control Point, Yucca Lake, and the Construction Facilities.

The potential geologic repository at the Yucca Mountain site, which could involve construction and operation of a geologic repository for spent nuclear fuel and high-level waste on NTS land and other federal land on the western boundary of the NTS, is also considered in this cumulative impacts analysis. Considering the relatively isolated location of the NTS, future new offsite activities (other than the potential geologic repository at Yucca Mountain) are assumed to be of limited scope.

The following cumulative impacts analysis considers the potential incremental effects from the proposed SNF management facilities and the proposed Expended Core Facility in detail. The potential incremental impacts from activities proposed in the Five-Year Plan, and Master Plan the potential geologic repository at the Yucca Mountain site, and from future offsite activities are assessed in a more qualitative manner.

5.16.1 Centralization Alternative

Separate analyses of potential cumulative impacts from the Centralization Alternative against the environmental baseline conditions presented in Chapter 4 are provided below.

5.16.1.1 Land Use. Construction of the proposed SNF management facilities would

require the dedication of approximately 90 acres (0.36 square kilometer) of undeveloped land on the NTS. Construction of the proposed Expended Core Facility would require the dedication of an additional 30 acres (0.12 square kilometer) of undeveloped land, increasing the total land requirement to 120 acres (0.48 square kilometer). This represents less than 1 percent of the roughly 450,000 acres (1,800 square kilometers) of undeveloped land remaining on the 864,000 acre (3,500 square kilometers) NTS. Additional unknown areas of undeveloped land, generally parcels of under 100 acres (0.4 square kilometer), might have to be dedicated to some of the activities proposed in the Five-Year Plan and Master Plan. Many of these proposed activities do not require the dedication of undeveloped land. Land on the southwestern part of the NTS has already been allocated for the potential Yucca Mountain repository and current site characterization for a potential geologic repository at the Yucca Mountain site.

Considering the large area of undeveloped land on the NTS, the cumulative dedication of land to all reasonably foreseeable activities on NTS would not likely serve to further limit the availability of land on the NTS for future development. Large areas of undeveloped land are available for development off of the NTS, and any future offsite development coupled with the proposed onsite development discussed above is not likely to create regional land shortages that could severely limit future regional development.

5.16.1.2 Occupational and Public Health. The annual collective effective dose

equivalent from the existing NTS facilities to the population within 50 miles (80 kilometers) of the NTS is 0.0052 person-rem. Added to this baseline, operation of the proposed SNF management facilities might contribute an additional 0.082 person-rem, increasing the cumulative effective dose to 0.087 person-rem.

The annual collective effective dose equivalent from the existing NTS facilities to a potential maximally exposed individual at the site boundary is 0.011 millirem per year. Operation of the proposed SNF management facilities might contribute an additional 0.12 millirem per year, resulting in a cumulative annual dose of 0.13 millirem per year to this maximally exposed individual.

The total annual baseline worker dose seen from normal NTS operations is about 4 person-rem. The total annual SNF management facility worker dose is expected to be roughly 32 person-rem. Hence, the cumulative annual dose might be 36 person-rem.

Over the planned 40-year operational lifetime of the SNF management facility, a total population dose of 3.5 person-rem will be observed from continuous operation of the existing NTS facilities and the SNF management facility. This equates to a risk of fatal cancer of 4.4 x 10-5 over the 40-year span. For the maximally exposed individual, the total dose over the 40-year period equates to a risk of fatal cancer of 2.6 x 10-6. For the SNF management worker, the total dose over the 40-year span corresponds to a risk of fatal cancer of 6.4 x 10-4.

Additional radiological impacts are not expected from operation of the proposed Expended Core Facility. Analysis has shown that the dose to all individuals considered (workers, and offsite individuals) from Expended Core Facility operations might be much less than one millirem per year.

5.16.1.3 Noise. Increases in noise levels from construction and operation of the SNF

management facilities and the Expended Core Facility would be limited to temporary, minor construction noise and small increases in traffic noise occurring along various access routes to the NTS due to increases in employment. Because of the NTS's large size and sparsely inhabited surroundings, any cumulative noise levels generated on the NTS by the proposed SNF management facilities, the proposed Expended Core Facility, the potential geologic repository at the Yucca Mountain site, and activities proposed in the Five-Year Plan and Master Plan would not propagate offsite at levels that would impact the general population. Although the cumulative offsite noise level attributed to future offsite activities can not be estimated, the potential incremental addition attributable to the proposed SNF management facilities would be minimal. Minor increases in traffic noise on U.S. Route 95 could be possible due to increases in activity on and near the NTS.

5.16.1.4 Groundwater and Surface Water Resources. Operation of the proposed SNF

management facilities would require the withdrawal of an estimated 3.6 million gallons per year (13.6 million liters per year) of groundwater from the Ash Meadows Subbasin. Operation of the proposed Expended Core Facility would require the withdrawal of an estimated additional 2.5 million gallons per year (9.5 million liters per year) from that subbasin, resulting in a combined withdrawal of an estimated 6.1 million gallons per year (23.1 million liters per year). The water demands for the potential geologic repository at the Yucca Mountain site would be met by the Alkali Flat Furnace Creek Ranch Subbasin and therefore would not contribute to the cumulative water withdrawals from the Ash Meadows Subbasin. Information concerning the water demands of activities in the Five-Year Plan, Master Plan, or future offsite activities is not available.

Although total withdrawals of groundwater from the Ash Meadows Subbasin have not exceeded the subbasin perennial yield, localized withdrawals of groundwater in the Frenchman Flat hydrographic area of the Ash Meadows Subbasin have exceeded the estimate of precipitation recharge for the area. This recharge estimate was exceeded for more than thirty years with no decline in static water levels. Accurate measurement of static water levels are, however, precluded by numerous conditions on the NTS. Because of hydrogeologic complexities, regional groundwater flow at the NTS is not constrained by the hydrographic basins which are defined by local topography. Therefore any potential groundwater overdraft in the Frenchman Flat hydrographic area indicated by previous yield estimates are likely be made up by untapped groundwater from neighboring hydrographic basins. Localized impacts could occur if the perennial yield of Frenchman Flat hydrographic area is exceeded. Potential impacts include depletion of water stored locally in the regional aquifer, removal of that groundwater from other potential uses, and the potential modification of the rate and direction of contaminant migration resulting from underground nuclear testing. The complex issues of groundwater contamination and use are being addressed in the Resource Management Plan being prepared in conjunction with the NTS site-wide EIS.

5.16.1.5 Biotic Resources. Construction of the proposed SNF management facilities

would require the disturbance of approximately 90 acres (0.36 square kilometer) of desert habitat supporting flora and fauna characteristic of the ecotone between the Mohave Desert and the Great Basin. Construction of the proposed Expended Core Facility would require the disturbance of an additional 30 acres (0.12 square kilometer) of desert habitat, resulting in a combined conversion of 120 acres (0.48 square kilometer) of terrestrial habitat to developed uses.

Additional areas of desert habitat would be lost during construction of activities proposed in the Five-Year Plan and Master Plan, during construction of the potential geologic repository at the Yucca Mountain site, and during future offsite construction activities. Considering the broad extent of desert habitat on and surrounding the NTS, the cumulative loss of desert habitat would be minimal.

The NTS lies within the range of the desert tortoise, a federally listed threatened species. If the desert tortoise occurred in areas subject to development, tortoises could be injured from construction activities. The proposed SNF management facilities (and the proposed Expended Core Facility) would be constructed at the edge of the tortoise's range, however, and few have been found in the affected area. Habitat losses due to construction of the proposed SNF management facilities and other proposed onsite and offsite construction activities could result in a slight cumulative loss of habitat for the desert tortoise. The U.S. Fish and Wildlife Service would be consulted in accordance with Section 7 of the Endangered Species Act prior to construction of the potential SNF management facilities to ensure that any potential cumulative effect on desert tortoise populations would be minimal. The U.S. Fish and Wildlife Service would also have to be similarly notified and given an opportunity to comment prior to construction of the potential geologic repository at the Yucca Mountain site and prior to any other major construction activities.

5.16.1.6 Air Quality. The potential cumulative air emissions from the proposed SNF

management facilities and the proposed Expended Core Facility would not result in an exceedance of the National Ambient Air Quality Standards or Nevada state criteria. Also, there would be no exceedance of Federal National Emissions Standards for Hazardous Air Pollutants or DOE radiological standards. Air emissions from the other planned activities have not yet been defined.

5.16.1.7 Socioeconomics. Operation of the proposed SNF management facilities might

generate up to 800 new jobs during the year 2005 and beyond. Operation of the proposed Expended Core Facility might generate up to 562 additional jobs during that year, resulting in a combined increase of up to 1,362 new jobs. The 7,091 jobs presently forecasted for the NTS in the year 2005 might be increased by 19 percent, to as much as 8,453 jobs. The 752,356 jobs presently forecasted for the surrounding area in the year 2005 might be increased by less than 1 percent, to as much as 753,718 jobs. Additional employment increases could also result from the potential geologic repository at the Yucca Mountain site, activities proposed in the Five-Year Plan and Master Plan, and new offsite activities, but specific estimates are not available.

The cumulative effect of the employment increases discussed above would depend on future actions at the NTS and throughout the regional economy. These employment increases could cause minor fluctuations in employment and housing demands. However, activities at the NTS generally have a relatively modest effect on long-term regional economic growth and productivity in Clark County because of the implicit growth projections in the services and retail trade sectors driving long-term growth in the Las Vegas Metropolitan Statistical Area. Additionally, in recent years the shutdown of nuclear testing activities at the NTS has caused employment levels to fall. These losses have not been considered in long-term employment forecasts. If nuclear testing activities do not resume at the NTS, the projected employment increases noted above could be offset by employment losses.

5.16.1.8 Transportation. An estimated 4.0 x 10-4 and 1.4 x 10-3 accident occupational

fatalities and accident nonoccupational fatalities might occur over the 40-year life of the proposed SNF management facilities due to the transportation of hazardous material to the facilities. This does not include fatalities due to leakage of hazardous waste. Similar data are not available for the other planned activities.

5.16.1.9 Waste Management. Operation of the proposed SNF management facilities

would generate an estimated 203 cubic meters (266 cubic yards) per year of low level waste and an estimated 16 cubic meters (21 cubic yards) per year of transuranic waste. Operation of the proposed Expended Core Facility would generate an additional 425 cubic meters (556 cubic yards) of low level waste (for a combined total by both facilities of 628 cubic meters (821 cubic yards)) but would not generate any additional transuranic waste. No other radioactive waste, including high level waste or mixed waste, would be generated by either facility. Comparable data for the potential geologic repository at the Yucca Mountain site or for offsite activities or activities proposed in the Five-Year Plan and Master Plan is not available. All wastes generated by the proposed SNF management facilities and other planned activities on the NTS would be treated and disposed of in accordance with all applicable Federal and state regulations.

5.16.1.10 Other Resources. The absence of impacts, or very minimal impacts, from the

proposed SNF management facilities to cultural resources, aesthetic and scenic resources, utilities, and geologic resources ensures that their potential contribution to cumulative impacts affecting these resources would be negligible.

5.16.2 Regionalization Alternative

Because impacts from the proposed SNF management facilities under the Regionalization Alternative would be equal to or less than those under the Centralization Alternative, the potential cumulative impacts would also be equal or less. Generally, the Regionalization Alternative requires less construction and smaller scale operations, and the potential for cumulative impacts is therefore less.

5.17 Adverse Environmental Effects That Cannot Be Avoided

5.17.1 Overview

This chapter discusses potentially unavoidable adverse impacts to the environment resulting from construction and operation of the proposed SNF facilities at the NTS under the Centralization and Regionalization Alternatives. Unavoidable adverse impacts are impacts which cannot be mitigated by changes in project design, operation, or construction, or by other measures.

5.17.2 Centralization Alternative

Operation of the proposed SNF facilities at the NTS under the Centralization Alternative would increase the radiation dose rate to the maximally exposed individual by 0.12 millirem/year, resulting in only a minimal increase in cancer risk. The number of fatal cancers per year of operations on the NTS from existing sources and the SNF facilities would be 4.4 x 10-5.

Construction of the proposed SNF facilities would require the disturbance of approximately 90 acres (0.36 square kilometer) of undeveloped land. Although this represents less than 1 percent of the undeveloped land on NTS, it would eliminate potential terrestrial wildlife habitat, including habitat potentially suitable for the federally listed desert tortoise. It would also require the dedication of a small land parcel potentially suitable for other construction projects, but similar land parcels are abundant on the NTS.

Operation of the proposed SNF facilities would require the withdrawal of an estimated 3.6 million gallons (13.6 million liters) per year of groundwater from the Ash Meadows Subbasin. Existing localized withdrawals of groundwater from Frenchman Flat hydrographic area of this subbasin already exceed the estimate of precipitation rechange for the area. However, the total withdrawal from the Ash Meadows Subbasin does not exceed its total perennial yield. Any water withdrawn would therefore not be discharged at Ash Meadows and the other discharge points in the deserts southwest of NTS.

The potential impacts from the Centralization Alternative to the other environmental resources discussed in Chapter 5 are not unavoidable adverse impacts.

5.17.3 Regionalization Alternative

Potential unavoidable adverse impacts associated with the Regionalization Alternative would resemble those discussed above for the Centralization Alternative. The extent of the impacts could be less due to the reduced land requirements, reduced extent of construction disturbance, and reduced scale of operations.

5.18 Relationship Between Short-Term Use of the Environment

and the Maintenance and Enhancement of Long-Term Productivity

Implementation of any of the SNF management alternatives would cause some adverse impacts to the environment and permanently commit certain resources. These resources include use of the environment and those associated with construction and operation of the SNF management facilities.

The proposed alternatives for SNF management would require the short-term use of resources including energy, construction materials, and labor in order to achieve the objective of safety managing SNF to minimize the risk to workers, the public, and the environment.

Development of new SNF interim management facilities would commit lands to those uses from the time of construction through the cessation of operations, at which time the facilities could be converted to other uses or decontaminated, decommissioned, and the site restored to its original land use.

5.19 Irreversible and Irretrievable Commitments of Resources

5.19.1 Overview

This chapter discusses the irreversible and irretrievable commitments of resources resulting from the use of materials that can not be recovered or recycled, or that must be consumed or reduced to irrecoverable forms.

5.19.2 Centralization Alternative

Construction and operation of SNF facilities under the Centralization Alternative would require commitments of electrical energy, fuel, concrete, steel, sand, gravel and miscellaneous chemicals. Groundwater to operate the SNF facilities would not be discharged in the deserts to the southwest of NTS. More detailed analyses would be required to determine irreversible effects on localized groundwater availability. The land dedicated to the SNF facilities would become available for other rural uses following closure and decommissioning.

5.19.3 Regionalization Alternative

Irreversible and irretrievable commitments of resources associated with the Regionalization Alternative would resemble those discussed above for the Centralization Alternative. However, the extent of these resource commitments could be less, due to the reduced land requirements and reduced scale of operations.

5.20 Potential Mitigation Measures

5.20.1 Pollution Prevention

The DOE Nevada Field Office (DOE/NV) published a Waste Minimization and Pollution Prevention Awareness Plan in June 1991 to reduce the quantity and toxicity of hazardous, mixed, and radioactive wastes generated at DOE/NV facilities. The plan is designed to reduce the possible pollutant releases to the environment and thus increase the protection of employees and the public. All DOE/NV contractors and NTS users that exceed the EPA criteria for small-quantity generators are establishing their own waste minimization and pollution prevention awareness programs that are implemented by the DOE/NV plan. Contractor programs ensure that waste minimization activities are in accordance with Federal, state, and local environmental laws and regulations, and DOE Orders (DOE/NV 1993c).

Additional goals include the promotion and use of nonhazardous materials, establishment of a baseline of waste generation data, calculations of annual reductions of wastes generated, and implementation of recycling programs. Goals also include incorporation of waste minimization concepts and technologies in planning and design of new processes and facilities, and in upgrades of existing facilities. A waste minimization task force composed of representatives from each contractor and NTS user has been established to coordinate DOE/NV waste minimization and pollution awareness activities (DOE/NV 1993c).

5.20.2 Potential Mitigation Measures

Potential impact avoidance and mitigation measures are addressed in Chapter 5, Sections 1 through 15 as appropriate.

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7.0 ABBREVIATIONS AND ACRONYMS

oC	degrees Celsius
CFR	Code of Federal Regulations
Ci	curie(s)
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
EIS	environmental impact statement
ECF	Expended Core Facility
EPA	U.S. Environmental Protection Agency
yF	degrees Fahrenheit
FEMA	Federal Emergency Management Agency
g	gram
gal	gallon(s)
hr	hour
INEL	Idaho National Engineering Laboratory
kg	kilogram
km	kilometer
kv	kilovolt
y	liter
m	meter
m3	cubic meter
mi	mile
mi2	square mile
min	minute
mph	miles per hour
mR	milliroentgen
mrem	millirem
MTHM	metric tons of heavy metal
MW	Megawatt
nCi	nanocurie
NEPA	National Environmental Policy Act
NRC	Nuclear Regulatory Commission
NTS	Nevada Test Site
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PCB	polychlorinated biphenyl
pCi	picocurie(s)

PEIS	Programmatic Environmental Impact Statement
PM10	particulate matter less than 10 microns in diameter
ppm	parts per million
RCRA	Resource Conservation and Recovery Act
SNF	spent nuclear fuel
SRS	Savannah River Site
TVA	Tennessee Valley Authority
ug	micrograms
USGS	U.S. Geological Survey
yr	year

OAK RIDGE RESERVATION

FIGURES

TABLES

#1. INTRODUCTION

This part assesses the impacts of contruction and operation of proposed spent nuclear fuel (SNF) facilities at the Oak Ridge Resevation (ORR). The ORR is being evaluated for these facilities because of the area available, the appparently suitable site environmental parameters, previous U.S. Department of Energy activities involving radioactive materials at the site, and the planned long-term government control of the site.

This appendix is organized as follows. Chapter 1 is the introduction, Chapter 2 sets the stage for the area under analysis by providing an overview of the ORR and a discussion of the Regulatory Framework and the SNF Management Program, and Chapter 3 explains the SNF alternatives being considered at the site.

Chapter 4 describes the human and natural environment that could be affected as a result of the introduction of an SNF facility at the ORR. Environmental parameters such as water resources, socioeconomics, biological resources, and air quality are examples of those characterized.

Chapter 5 enumerates the environmental consequences that might be anticipated, summarizes the cumulative impacts, describes unavoidable adverse impacts, and describes the irreversible and irretrievable committment of resources that might be anticipated if an SNF facility were built at the ORR. Chapter 6 contains the references used to develop this part of the environmental impact statement. Chapter 7 contains a list of abbreviations and acronyms used in this part of the environmental impact statement.

2. OAK RIDGE RESERVATION SITE BACKGROUND

2.1 Overview

2.1.1 Site Description

The Oak Ridge Reservation (ORR) is located on approximately 34,667 acres (140 square kilometers) of federally owned land within the incorporated city limits of Oak Ridge, Tennessee (see Figure 2.1-1). The City of Oak Ridge and the ORR lie between the Cumberland and Southern Appalachian mountain ranges. Knoxville is located approximately 25 miles (40 kilometers) southeast of the ORR and is the largest city in the area. The population varies within the five counties surrounding the ORR. The area around Knoxville is a heavily populated and highly developed urban area, whereas the area surrounding the ORR is sparsely populated, with the exception of the city of Oak Ridge, which is considered to have medium density population. The two main land uses in the five counties surrounding the ORR are forestry and agriculture.

Within the ORR there are three primary complexes: the Y-12 Plant, the K-25 Site (formerly the Oak Ridge Gaseous Diffusion Plant), and the Oak Ridge National Laboratory (ORNL) (see Figure 2.1-2). Currently these facilities are being used for research, development, and production.

The Y-12 Plant is located on the eastern portion of the ORR known as Bear Creek Valley. The Y-12 Plant serves as a key manufacturing technology center for the development and demonstration of unique materials, components, and services of importance to DOE and the nation. This mission is accomplished through the reclamation and storage of nuclear materials, the manufacture of components to the nation's defense capabilities, support to national security programs, and services provided to other customers as approved by DOE (MMES 1994a).

The K-25 Site is located on the northwestern portion of the ORR. Its mission is to provide a base of operation for the Energy Systems Environmental Restoration and Waste Management programs, thus serving as the "platform" for the restoration of the environment and management of DOE wastes through leadership and central management of the Environmental Restoration and Waste Management and Technology Development Programs in support of DOE, sites managed for DOE by Energy Systems, other elements of the Federal Government, and the public. The Toxic Substances Control Act incinerator is managed by and located on the K-25 Site (MMES 1994a).

Figure 2.1-1. Oak Ridge Reservation regional map. Figure 2.1-2. Oak Ridge Reservation site and transportation.

The ORNL is located in the southern portion of the ORR. The primary mission of ORNL is to perform leading edge research and development in support of nonweapons roles of DOE (MMES 1994a). The ORNL uses test and experimental reactors to perform research and for small-scale radioisotope production activities. The amount of spent nuclear fuel (SNF) generated by these facilities, the amount expected to be generated through the year 2035, and accommodations being undertaken at the present time to store the fuel currently being generated are discussed in the following sections.

The buildings located off the ORR but owned and/or operated by the U.S. Department of Energy (DOE) are 1) the Scarboro Facility, 2) the Central Training Facility, 3) the Transportation Safeguards Division Maintenance Facility, and 4) some ancillary and administrative facilities and structures. The majority of the facilities used by various plant protection and security groups are located within the plant's boundary. Other offsite facilities include the DOE Oak Ridge Operations Office, the DOE Office of Scientific and Technical Information, the Oak Ridge Associated Universities facilities, the American Museum of Science and Energy, the prime contractor's "Townsite" facilities, the National Oceanic and Atmospheric Administration's Atmospheric Turbulence and Diffusion Laboratory, and others. With the exception of the Federal Office Building and space leased from the private sector, all facilities are located on DOE-owned land.

The proposed site of the SNF management facility is located on 100 acres (0.40 square kilometer) of land designated as the West Bear Creek Valley site (see Figure 2.1-2) (La Grone 1994; MMES 1994b). The proposed SNF storage facility will require 90 of the 100 acres (0.36 of the 0.40 square kilometer) set aside for the facility (Johnson, V. 1994).

The proposed SNF management facility is on Bear Creek Road adjacent to the Clinch River on the west end of the ORR. The westernmost boundary of the proposed SNF facility is less than 1 mile (1.6 kilometers) from the ORR boundary. Across Bear Creek Road from the proposed SNF management facility there is a privately owned industrial park (MMES 1994b).

2.1.2 Site History

The ORR was originally purchased in the early 1940s to house the large-scale production of fissionable material for the first nuclear weapon in the world. The original tract of land purchased was 56,833 acres (230 square kilometers). Portions of the original tract were used to build the City of Oak Ridge for the people who constructed and operated the ORR. Residential and business areas of the city were sold, and the ORR has been reduced to its present size.

ORNL began in 1943 as the Clinton Laboratories, a pilot plant for testing and development of the plutonium-239 production and chemical separations processes. Major facilities at the ORNL included the X-10 Graphite Reactor, a chemical pilot plant, and numerous support laboratories and shops. The ORNL's initial mission was fulfilled by 1945, but because of its unique capabilities, new research and development programs were initiated in energy, materials, and environmental technology (DOE 1988).

Since 1945 emphasis at ORNL has been on exploration of the use of nuclear science and technology, which continues as a major component of research and development of the laboratory. A number of additional nuclear reactors and supporting facilities have been built and operated at ORNL since the original mission associated with the Manhattan Project. Research and development in nuclear science and technology is supported currently by one operating research reactor, the High Flux Isotope Reactor. ORNL has proposed the Advanced Neutron Source, which would take over many of the tasks now carried out by the High Flux Isotope Reactor (Brown 1994a; Hoel 1994).

In 1943 the Y-12 Plant was constructed as part of the Manhattan Project. The Y-12 Plant separated fissionable isotopes of uranium-235 by the electromagnetic process, which was used in the world's first atomic bomb, detonated on August 5, 1945 (MMES 1990; DOE 1987). Since that time Y-12 has developed into a highly sophisticated nuclear weapons component manufacturing and development engineering organization and currently is used for weapons disassembly.

The Oak Ridge Gaseous Diffusion Plant, now the K-25 Site, was used to produce enriched uranium for U.S. nuclear weapons. It also provided an industrial toll enrichment service, in which uranium was enriched for use in nuclear-powered reactors around the world. In 1987, the Oak Ridge Gaseous Diffusion Plant was permanently shut down.

2.1.3 Mission

The missions of the primary plant complexes within ORR are:

- Energy Research and Development at ORNL.
- Reclamation and Storage of Nuclear Material, Manufacturing of Defense Hardware, and National Security, Technology Transfer, and Work for Others Programs at Y-12.
- Environmental Restoration and Waste Management at the K-25 Site (MMES 1994a).

The mission of ORNL includes services that only research reactors provide, including, 1) the production of transuranium isotopes used in basic research, medical, defense, and industrial applications, 2) neutron scattering research to determine fundamental structure and properties of materials, 3) production of unique isotopes for medical treatment and research, 4) production of special commercial isotopes, and 5) irradiation of structural and fuel materials for fusion energy reactors and advanced nuclear reactors (Brown 1994a; Hoel 1994).

2.1.4 Oak Ridge Reservation Operations Management

Martin Marietta Energy Systems, Inc., operates the major facilities at the ORR (Y-12 Plant, K-25 Site, and ORNL). They are under contract to and administered by the DOE Oak Ridge Operations Office. Current missions and functions can be grouped into the following four categories: defense production activities; environmental management activities; other DOE activities; and work for others.

2.2 Regulatory Framework

The National Environmental Policy Act (NEPA) of 1969 (42 USC 4321-4347, as amended) provides Federal agency decision makers with a process to systematically consider the potential environmental consequences of agency decisions. The DOE has prepared this environmental impact statement (EIS) in conformance with the requirements of NEPA to evaluate the potential impacts of programmatic decisions on the management of SNF. This EIS provides the necessary background, data, and analyses to help decision makers understand the potential environmental consequences of each alternative.

On October 22, 1990, the DOE published a Notice of Intent in the Federal Register (FR 1990) announcing its intent to prepare a programmatic EIS addressing environmental restoration and waste management (including SNF management) activities across the entire DOE complex. On October 5, 1992, the DOE published a Notice of Intent in the Federal Register (FR 1992) announcing its intent to prepare an EIS addressing environmental restoration and waste management and SNF activities at the Idaho National Engineering Laboratory. For further programmatic discussion of this topic, see Volume 1.

Significant state environmental and nuclear materials management laws applicable to the

ORR include the following (listed alphabetically):

- Air Pollution Control Regulations (Chapter 1200-3)
- Air Quality Act (Title 68 Chapter 201-101)
- Emergency Rules--Hazardous Substance Remedial Action (Chapter 1200-1-13)
- Emission Standards and Monitoring Requirements for Additional Control Areas (Chapter 1200-3-19)
- Hazardous Substance Site Remedial Action (Chapter 1200-1-13)
- Hazardous Waste Management (Chapter 1200-1-11)
- Licensing Requirements for Land Disposal of Radioactive Waste (Chapter 1200-2-11)
- New Source Performance Standards (Chapter 1200-3-16)
- Prevention of Hazards and Pollution (Chapter 1200-1-6)
- Rules and Regulations Applied to Tennessee Codes Annotated -69-1-1 (Chapter 1200-4-8)
- Solid Waste Processing and Disposal (Chapter 1200-1-7)
- Underground Storage Tank Program (Chapter 1200-1-15)
- Visible Emission Regulations (Chapter 1200-3-5)
- Volatile Organic Compound (Chapter 1200-3-18)

2.3 Spent Nuclear Fuel Management Program

In the past, reactor-irradiated nuclear materials, which include SNF and reactor-irradiated target material, have been stored prior to reprocessing activities to recover plutonium, tritium, and other isotopes. In the past several years, however, the DOE has either phased out or stopped its reprocessing of these materials. With this change, reactor-irradiated nuclear materials were being stored for longer periods of time than originally planned. The amount of reactor-irradiated nuclear materials and the conditions of storage for the materials were in question throughout DOE facilities.

In an effort to assess whether extended storage conditions for reactor-irradiated nuclear materials are safe (i.e., whether protection exists for workers, the public, and the environment), the DOE commissioned a study. This assessment also grouped any vulnerabilities of the storage conditions into three categories where management attention could be directed: less than 1 year, 1 to 5 years, and greater than 5 years. In November 1993, the DOE published the Spent Fuel Working Group Report on Inventory and Storage of the Department's Spent Nuclear Fuel and other Reactor Irradiated Nuclear Materials and Their Environmental, Safety and Health Vulnerabilities, hereafter referred to as the Spent Fuel Working Group Report, as a result of the assessment efforts (DOE 1993b; 1994b).

As a result of the Spent Fuel Working Group Report, a Plan of Action to Resolve Spent Nuclear Fuel Vulnerabilities was also commissioned to address what was discovered in the original Working Group Report. Phase I of the Plan of Action to Resolve Spent Nuclear Fuel Vulnerabilities was published in February 1994. Phase II and Phase III were issued April 1994 and October 1994, respectively. To address the vulnerabilities identified in the Spent Fuel Working Group Report, individual action plans were developed to reflect the DOE's sense of urgency, concern for worker protection, commitment to minimize environmental impacts, and need for compatible long-term solutions.

The ORR was assessed as part of the Spent Fuel Working Group Report. SNF located on the ORR is currently stored in facilities at the ORNL. The SNF at ORR is primarily spent fuel from research or experimental reactors that are operating or have operated at ORNL. Samples of SNF left over from research on fuel elements removed from commercial or demonstration reactors utilized by DOE predecessor agencies for advancement of nuclear science are also present. In the past, most of the SNF from the Oak Ridge research and experimental reactors was chemically processed to recover fissile materials at Savannah River Site (Brown, 1994a; Hoel 1994).

This section describes the status of the SNF at the ORR using the information presented in the Spent Fuel Working Group Report, the Plan of Action to Resolve Spent Nuclear Fuel Vulnerabilities, the Spent Fuel Inventory Data developed for the SNF EIS, and through discussions with ORR. If fuel can be contact handled, it has not been listed in the Spent Fuel Inventory as SNF. The SNF management program at ORR utilizes 10 facilities for storage. These facilities and their SNF contents are summarized on Table 2.3-1.

2.3.1 Building 3525 - Irradiated Fuels Examination Laboratory

This two-story brick structure was built in 1963 and contains hot cells. The facility mission continues to be disassembly and examination of irradiated fuel and components. Building 3525 contains 1 unit of research reactor fuel in the form of fuel samples and targets (DOE 1993b; Wichmann 1995a, b).

2.3.2 Building 4501 - High-Level Radiochemical Laboratory

Constructed in 1951, this facility contains centrally located hot cells supported by various laboratories capable of handling radioactive materials. SNF is in dry storage at this facility. Building 4501 contains 0.006 metric tons of heavy metal (MTHM) of DOE-owned commercial fuel (DOE 1993b; Wichmann 1995a, b).

2.3.3 Building 7920 - Radiochemical Engineering Development Center

The Radiochemical Engineering Development Center is a multipurpose hot cell facility with equipment, shielding, and containment provisions to safely process and store significant quantities of highly radioactive targets. This facility was specifically built to prepare and process targets from the High Flux Isotope Reactor. Building 7920 contains 0.024 MTHM of research reactor fuel in the form of fuel samples in dry storage (DOE 1993b; Wichmann 1995a, b).

2.3.4 Dry Storage Facilities 7823A, 7827, and 7829

Now closed to further storage, these shielded, retrievable storage facilities are stainless-steel dry wells placed in the ground in Solid Waste Storage Area 5 North. They vary from 8 to 30 inches (20 to 76 centimeters) in diameter and from 10 to 15 feet (3 to 4.6 meters) in depth. The wells are placed on a concrete pad and are held in place by concrete collars or slabs and are surrounded by dirt. Spent fuel and other materials were placed in the wells beginning in 1972. Facility 7823A contain 0.0008 MTHM; facility 7827 contains 0.0837 MTHM; and facility 7829 contains 0.0137 MTHM. Activities to address the vulnerabilities in these facilities include 1) transferring the fuel, 2) adding a new inner liner and relocating fuel in modified units, and 3) overpacking any fuel in suspect condition. These activities are expected to be completed in fiscal year 1996 (DOE 1994b; 1993b; Wichmann 1995a, b).

Table 2.3-1. Oak Ridge Reservation SNF Storage Facilities.

Facility name	Material stored at facility	Heavy metal mass (MTHM)
High Flux Isotope Reactor (HFIR) Pool	HFIR fuel	0.45
Bulk Shielding Reactor (BSR) Pool	BSR & ORR fuel	0.01
Molten Salt Reactor Experiment (MSRE)	MSRE fuel	0.037
Bldg. 4501	Misc. LWR fuels	0.006
Tower Shielding Reactor (TSR)	TSR fuel	0.0092
Facility 7823A	Misc. fuel	0.0008
Facility 7827	Misc. fuel	0.0837
Facility 7829	Peach Bottom	0.0137
Bldg. 7920	Dresden-1 fuels	0.024
Bldg. 3525	Misc. fuels	
Solid Waste Storage Area 6	KEMA Suspension Test Reactor fuela	0.037

Source: Wichmann (1995a,b)

a. See Section 2.3.5.6.

2.3.5 Research Reactors

Six existing reactors and one planned reactor are expected to be generating and storing SNF at the ORNL. They are the High Flux Isotope Reactor (currently operating), the Tower Shielding Reactor No. II (shut down in 1992), the Bulk Shielding Reactor (shut down in 1991), the Oak Ridge Research Reactor (shut down in 1987), the Molten Salt Reactor Experiment (shut down in 1969), the KEMA Suspension Test Reactor, and the Advanced Neutron Source Reactor (planned to start up in 2002 or 2003) (ANS 1988).

2.3.5.1 High Flux Isotope Reactor. The High Flux Isotope Reactor is a beryllium-reflected, light water cooled and moderated, flux-trap-type reactor. The reactor uses aluminum-clad fuel plates containing highly enriched uranium-235. The reactor became operational in 1965 and its current power level is 85 megawatts. Reactor missions include production of isotopes for medical and industrial applications, neutron-scattering experiments, and various material irradiation experiments (ANS 1988; DOE 1993b).

The High Flux Isotope Reactor is operating. At the present time there are 62 fuel assemblies amounting to 0.45 MTHM from the research reactor fuel in onsite wet storage. The High Flux Isotope Reactor currently does not use onsite dry storage. If the reactor continues operation through the year 2035, the predicted SNF production will be an additional 110 fuel assemblies totalling 1.58 MTHM. (Holt 1993; ORNL 1992a; Wichmann 1995a, b).

Onsite storage at the reactor facility would have to be expanded to accommodate this projected SNF generation rate. At the present time, reracking the existing storage facility and installing modular dry-storage units at the High Flux Isotope Reactor are being considered. With the installation of the dry-storage units, the potential for future expansion of storage facilities is expected to continue indefinitely (ORNL 1992a).

In the past, SNF assemblies were shipped in casks via truck to the Savannah River Site, and the baseline plan is to continue shipments there. However, the Savannah River Site has limited space and plans to accept only 20 fuel assembly shipments from the High Flux Isotope Reactor. If shipment of SNF to another DOE storage facility is precluded or the commencement of reracking at the High Flux Isotope Reactor is not approved by the DOE, the reactor will be required to shut down because the present pool storage racks cannot accommodate additional fuel after early 1995 (Clark 1994).

2.3.5.2 Tower Shielding Reactor No. II and Tower Shielding Facility Building 7708.

The 1 megawatt Tower Shielding Reactor No. II is a light water moderated, movable tank, research reactor which was shut down in 1992. There are no plans for resuming operations at this time. Tower Shielding Reactor No. II has no containment and was used at ground level or suspended from towers. The research included testing shielding designs and obtaining associated data (ANS 1988; DOE 1993b).

The Tower Shielding Reactor No. II was placed in standby in September 1992 pending DOE direction to prepare the facility for shutdown. At that time, the only existing Tower Shielding Reactor No. II fuel assembly was being stored in the reactor core. For handling and storage purposes, an element is an integral core assembly composed of 4 upper central plates, 4 lower central plates, 12 annular plates, a central plug, and 4 fuel plates. One element, 0.0092 MTHM, is being stored in the reactor core. The corrective actions associated with the vulnerabilities identified in the Spent Fuel Working Group Report for the Tower Shielding Reactor No. II and Tower Shielding Facility Building 7708 are: 1) implement access control to the Tower Shielding Reactor No. II area; 2) implement emergency operating procedures for the Tower Shielding Reactor, i.e., those applicable to a seismic event requiring the experimental area to be checked for hazards by knowledgeable staff before personnel enter the area; 3) implement radiation protection controls requiring that a survey be completed by Radiation Protection personnel to verify acceptable radiation levels prior to granting access to a radiological area; and 4) remove the fork-lift from Building 7708 to eliminate a potential fire hazard and transfer the fuel pins to the Y-12 area for long-term storage to eliminate the potential of an activity release in the same building (completed January 1994). All of these corrective actions plans have been completed and are being implemented (Holt 1993; ORNL 1994; DOE 1994b; Wichmann 1995a, b).

Present options being discussed for storage of this fuel include shipment to the Savannah River Site or onsite dry storage at ORNL. Because this reactor is shut down, no additional elements are expected to accumulate through the year 2035 (Holt 1993; ORNL 1994).

2.3.5.3 Bulk Shielding Reactor. The 2 megawatt Bulk Shielding Reactor is an open pool,

light water moderated and reflected, training and research reactor. This reactor was built in 1951 and shut down in 1991; there are no plans for resumption of operations at this time (ANS 1988; DOE/OSTI 1993; DOE 1993b).

The Bulk Shielding Reactor is shut down and currently has no elements in the reactor or in on-site dry storage. Seventy-three of 90 storage locations are occupied in the onsite wet storage. There are 41 elements from the Bulk Shielding Reactor and 32 elements from the Oak Ridge Research Reactor for a total of 0.010 MTHM in the storage area. As the reactor is shut down, no additional fuel is expected to be added to the inventory through the year 2035; therefore, no expansion of storage facilities onsite is expected (DOE 1993b; Wichmann 1995a, b).

2.3.5.4 Oak Ridge Research Reactor. The Oak Ridge Research Reactor was shut down

permanently in 1987 and has been defueled. Most of the fuel was transported to the Savannah River Site, but some of the fuel was transferred to the Bulk Shielding Reactor pool. Refer to the discussion of the spent fuel inventory in subsection 2.3.5.3 (Holt 1993; ANS 1988; ORNL 1992b).

2.3.5.5 Molten Salt Reactor Experiment. The Molten Salt Reactor Experiment

operated from June 1965 to December 1969 at a nominal power level of 8 megawatts. The purpose of the reactor was to test the practicality of a molten-salt reactor concept for central power station applications. The circulating fuel solution was a mixture of fluoride salts containing uranium fluoride as the fuel. The initial charge was uranium-235, but this was later replaced with a charge of uranium-233. Processing capabilities were included as part of the facility for on-line fuel additions, removal of impurities, and uranium recovery. Following reactor shutdown, the fuel and flush salts were drained to critically safe storage tanks and isolated (Hargrove 1993).

The inventory at the Molten Salt Reactor Experiment consists of approximately 4,650 kilograms (9,514 pounds) of fuels salt mixture. The uranium salt is predominantly uranium-233 (31 kilograms [68 pounds]) with lesser amounts of uranium-234, uranium-235, and uranium-238. The balance of the fuel salt is composed of lithium fluoride (LiF, 64.5 percent), beryllium fluoride (BeF_2, 30.3 percent), and zirconium fluoride (ZrF_4, 5.0 percent). The Molten Salt Experiment contains 0.037 MTHM as the reactor is shutdown, no additional SNF is expected to be generated through the year 2035 (DOE 1993b; Hargrove 1993; Wichmann 1995a, b).

Radioactive material migration has been detected from the storage tanks. This vulnerability could result in unnecessary personnel exposure. If left unabated, radiation levels could increase to a point where access would be difficult. ORNL is determining appropriate corrective actions and expects to implement its corrective action plan during fiscal year 1995 (DOE 1994b; 1993b).

2.3.5.6 KEMA Suspension Test Reactor. The KEMA Suspension Test Reactor was an

experimental fluidized bed test reactor. The fuel, consisting of one core, was placed in Solid Waste Storage Area 6 and totals 0.037 MTHM. The area of Solid Waste Storage Area 6 where the fuel was placed is being managed by DOE as part of waste area grouping 6, an environmental restoration program activity, under the Comprehensive Environmental Response, Compensation, and Liability Act. As the reactor is shutdown, no additional SNF is expected to be generated through the year 2035 (Wichmann 1995a, b).

2.3.5.7 Advanced Neutron Source Reactor. The Advanced Neutron Source Reactor is

currently in the conceptual design stage and has been proposed to be operational in the year 2002 or 2003. Its principal purpose will be for neutron beam experiments, but it will also be used for some isotope production (Holt 1993; DOE/OSTI 1993).

Since the current schedule projects initial operation of the Advanced Neutron Source Reactor in the year 2002 or 2003, spent fuel is not expected to be generated until 2004. Estimates are that 18 elements per year will be discharged. (For handling and storage purposes, an element is an integral core assembly composed of two concentric fuel plates.) A total of 576 SNF elements are predicted to be produced if the reactor is in operation from the years 2002 through 2035 (Holt 1993). As this reactor is in the conceptual design stage, the SNF expected to be generated is not included in the SNF Inventory Data.

3. SPENT NUCLEAR FUEL ALTERNATIVES

This chapter describes the spent nuclear fuel (SNF) management alternatives evaluated by the U.S. Department of Energy (DOE) for this Programmatic Environmental Impact Statement (EIS) that are applicable to the Oak Ridge Reservation (ORR). The ORR generates and stores SNF as a result of reactor research activities. Unlike the Hanford Site, the Idaho National Engineering Laboratory (INEL), and the Savannah River Site (SRS), SNF management is only a minor part of the ORR mission. Therefore, the No Action, Decentralization, and 1992/1993 Planning Basis alternatives could have minimal to no impact on ORR operations. However, the Regionalization and Centralization Alternatives would produce major impacts on ORR operations.

3.1 Description of Management Alternatives

3.1.1 Alternative 1 - No Action

The No-Action Alternative is restricted to the minimum actions necessary for the continued safe and secure management of SNF. As defined, this alternative stipulates no SNF shipments to or from DOE facilities. While the ORR generates and stores SNF as a result of reactor research activities, it does not receive SNF from offsite generators except occasionally in small quantities for specific research assignments. No offsite SNF would be shipped to the ORR under this alternative, nor would SNF be shipped offsite, which could affect the planned shipment of High Flux Isotope Reactor assemblies to the SRS. SNF storage capacity at the ORR for the existing High Flux Isotope Reactor would be adequate only through the year 2002. This could result in the shutdown of this reactor after this date. The proposed Advanced Neutron Source Reactor would need to consider this situation in the design and operation activities.

The environmental effects of the No-Action Alternative are essentially the same as those of current onsite SNF storage and are included in the affected environment discussions covering current site operations.

Implementation of the No-Action Alternative at ORR could lead to the shutdown of the High Flux Isotope Reactor as a result of filling the SNF storage capacity. If the High Flux Isotope Reactor were shutdown, it would eliminate the national capacity to provide transuranic isotopes, eliminate the only western-world source of some medical isotopes, and eliminate the nationally and internationally important capability for research and development in the structure of materials and irradiation effects on materials (Brown 1994a; Hoel 1994).

This alternative for the ORR is not analyzed or discussed further in this or subsequent chapters except in the Facility Accidents section, 5.15.

3.1.2 Alternative 2 - Decentralization

Decentralization involves storage of SNF at or close to generation sites. Under this alternative no offsite SNF would be shipped to the ORR nor would SNF be shipped offsite. The environmental effects of this alternative are the same as those of the No-Action Alternative. The environmental effects of current onsite SNF storage are included in the affected environment discussions covering current site operations. Consequently, this alternative is not analyzed or discussed further in this or subsequent chapters for the ORR. Construction of new SNF storage facilities could be initiated under this option.

The Decentralization Alternative would allow DOE to upgrade and/or replace facilities for the management of the SNF currently located on site. This alternative would allow for continued operation of the High Flux Isotope Reactor by allowing new dry-storage facilities for newly generated and existing SNF in the High Flux Isotope Reactor pool. To allow the High Flux Isotope Reactor to continue operations until a dry storage facility is available, a dry-storage cask may be acquired. DOE could propose an interim, retrievable, aboveground, dry-storage facility for consolidating the SNF at ORR. DOE could also prepare facilities as necessary for the characterization and packaging of SNF for interim storage. The fuel in the Molten Salt Reactor Experiment reactor would need conditioning and stabilization before being relocated to the new facility, or the Molten Salt Reactor Experiment fuel would need special storage facilities (Brown 1994a; Hoel 1994).

3.1.3 Alternative 3 - 1992/1993 Planning Basis

The 1992/1993 Planning Basis Alternative is DOE's documented 1992/1993 plan for the management of DOE and Naval SNF. This plan would include the shipment of SNF from the ORR to other DOE sites as necessary to permit continued operation of ORR research reactors. The environmental effects of current onsite SNF storage are included in the affected environment discussions covering current site operations. Under this alternative, the amount of SNF storage at ORR would not increase. Therefore, this alternative would not have a measurable impact on the environment since there would be no changes to current ORR operations. Consequently, this alternative is not analyzed or discussed further in this or subsequent chapters for the ORR.

At ORR, this alternative would be very similar to the Decentralization alternative except that some SNF would be shipped to SRS. The SNF currently stored at the High Flux Isotope Reactor and Bulk Shielding Reactor pools, and at the Tower Shielding Reactor would be shipped to SRS. Only 20 elements from the High Flux Isotope Reactor can be shipped to SRS unless other arrangements can be made. If the quantity of High Flux Isotope Reactor fuel that can be shipped to SRS is limited to 20 elements, then the High Flux Isotope Reactor will require dry-storage facilities to continue operation. DOE could prepare an interim, retrievable, aboveground, dry-storage facility for consolidating the SNF remaining at ORR. This facility would be similar to the one built under Alternative 2 except it would probably be smaller

(Brown 1994a; Hoel 1994).

3.1.4 Alternative 4 - Regionalization

3.1.4.1 Overview. The Regionalization Alternative consists of two subalternatives.

Subalternative A would distribute existing and new SNF between the Hanford Site, INEL, and SRS by SNF type. Under Subalternative B, SNF would be distributed to either an eastern or western regional site based on geographical location. SNF east of the Mississippi River would be shipped to the eastern regional site (i.e., SRS or ORR). SNF west of the Mississippi River would be shipped to the western regional site (i.e., Hanford Site, INEL, or Nevada Test Site [NTS]). Additionally all Naval SNF would be shipped to only one of the regional sites, but not both. A regional site will only receive all the Naval fuel if also selected as the Naval site. The ORR would be the alternative to the SRS as the eastern regional site, and the NTS would be the alternative to both the Hanford Site and INEL as the western regional site.

3.1.4.2 Regionalization Subalternative B. The following fuels would be transported to

the ORR for storage under the Regionalization Subalternative B:

- Naval-type SNF (if selected)
    - All, including from the INEL, shipyards, and prototypes
- Hanford Production SNF
    - From eastern sites
- Graphite SNF
    - From eastern sites
- DOE-owned commercial SNF
    - From eastern sites, including the West Valley Demonstration Project and B&W Lynchburg
- Experimental - Stainless Steel SNF
    - From eastern sites, including the Foreign Research Reactors, and non-DOE domestic research reactors
- Experimental - Zirconium SNF
    - From eastern sites, including the SRS
- Experimental - Other
    - From eastern sites
- SRS Production and Aluminum SNF
    - From eastern sites, including SRS, Brookhaven National Laboratory, Foreign Research Reactors, and non-DOE domestic research reactors.

All SNF presently in storage at DOE facilities would arrive at the ORR stabilized and canned to the extent necessary for safe transportation. However, this SNF may need to be uncanned, stabilized, prepared, and recanned at the ORR to ensure safe interim storage. New non-DOE domestic and Foreign Research Reactor SNF would arrive in a state necessary for safe transportation but uncanned. This fuel would be stabilized, prepared, and canned at the ORR to ensure safe interim storage. All fuel would be cooled for a minimum of 120 days prior to shipping and 5 years before being placed in dry storage.

The ORR currently has only limited-capacity facilities suitable for receiving, canning, storing, or supporting the research activities necessary for the safe management of SNF. As a result, a new SNF management complex would be built at the ORR under the Regionalization Subalternative B. The SNF management complex would include the following:

- SNF receiving and canning facility
- Technology development facility
- Interim dry storage area
- Expended Core Facility similar to the one currently at the INEL (if selected for Naval fuel receipt).

The SNF receiving and canning facility would receive SNF cask shipments from offsite and prepare the SNF for dry storage. A pool storage area would be included in this facility for cooling SNF before it is placed into dry storage, as necessary. The technology development facility would investigate the applicability of dry storage technologies and pilot-scale technology development for disposal of the various types of SNF. The interim dry storage area would consist of passive storage modules designed to safely store the SNF for 40 years. If ORR is selected for Naval fuel receipt, Naval SNF would be examined at the Expended Core Facility prior to being turned over for interim storage management.

The SNF management complex which would be built at the ORR under the Regionalization Alternative would have the same components as that built under the Centralization Alternative. The dry storage component would be smaller, however, due to the smaller SNF inventory that would be transported to the ORR under the Regionalization Alternative. The other components of the SNF management complex would be the same general size as those built under the Centralization Alternative. This is because the inventories of new uncanned fuel which would be sent to the ORR under the Regionalization and Centralization Alternatives would be very similar. Additionally, since the major portion of the potential radiological and chemical releases and waste generation rates are associated with these components, the Regionalization Alternative is not analyzed separately but is compared to the Centralization Alternative in a semiquantitative manner.

If the ORR was not chosen as the eastern regional site, all SNF at the ORR would be shipped to the SRS. An exception would be those fuels for which there is no available technology for stabilization to permit safe transport. There is a small quantity of SNF from the Molten Salt Reactor Experiment that is stored in tanks at the ORR. Currently, technology to stabilize this SNF for transport does not exist. Under this alternative, if ORR were to ship SNF to the SRS, this Molten Salt Reactor Experiment SNF would continue to be stored at the ORR until it could be stabilized for safe shipment.

Based on the projected schedule for operation of additional regional SNF storage facilities, the option for acquiring dry storage facilities at the ORR would be maintained to ensure continued High Flux Isotope Reactor operation (Brown 1994a; Hoel 1994).

3.1.5 Alternative 5 - Centralization

3.1.5.1 Overview. Under the Centralization Alternative, all existing and new SNF would

be shipped to one DOE site. There are five Centralization options considered in this EIS: the Hanford Site, the INEL, the SRS, the NTS, and the ORR. If the ORR was chosen as the centralization site, all SNF stored at the Hanford Site, INEL, SRS, and other sites currently storing DOE fuel would be transferred to the ORR.

3.1.5.2 Centralization Alternative Option D. The following fuels would be transported

to the ORR for storage under Centralization Alternative Option D:

- Naval-type SNF
    - From the INEL, shipyards, and prototypes
- Hanford Production SNF
    - From the Hanford Site
- Graphite SNF
    - From the INEL and the Public Service of Colorado
- DOE-owned commercial SNF
    - From the Hanford Site, INEL, West Valley Demonstration Project, and B&W Lynchburg
- Experimental - Stainless Steel SNF
    - From the Hanford Site, INEL, SRS, Foreign Research Reactors, and non-DOE domestic research reactors
- Experimental - Zirconium Clad SNF
    - From the INEL and SRS
- Experimental - Other
    - From the ORNL
- SRS Production and Aluminum Clad SNF
    - From the INEL, SRS, ORNL, Los Alamos National Laboratory, Brookhaven National Laboratory, Foreign Research Reactors, and non-DOE domestic research reactors.

All SNF presently in storage at DOE facilities would arrive at the ORR stabilized and canned to the extent necessary for safe transportation. However, this SNF may need to be uncanned, stabilized, prepared, and recanned at the ORR to ensure safe interim storage. New non-DOE domestic, Foreign Research Reactor, and Naval SNF would arrive in a state necessary for safe transportation but uncanned. This fuel would be stabilized, prepared, and canned at the ORR to ensure safe interim storage. All fuel would be cooled a minimum of 120 days prior to shipping and 5 years before being placed into dry storage. Additionally, Naval SNF would be examined at the ORR before it was turned over for interim storage management.

Although the ORR has a number of experimental and pilot facilities, probably none of them is suitable for receiving, canning, storing, or supporting research activities necessary for the safe management of SNF, unless they are extensively upgraded and expanded. As a result, a new SNF management complex would be built at the ORR under the Centralization Alternative Option D. The SNF management complex would include the following:

- SNF receiving and canning facility
- Technology development facility
- Interim dry storage area
- Expended Core Facility for Naval-type fuel similar to the one currently at the INEL.

The SNF receiving and canning facility would receive SNF cask shipments from offsite and prepare the SNF for dry storage. A pool storage area would be included in this facility for cooling SNF before it is placed into dry storage, as necessary. The technology development facility would investigate the applicability of dry storage technologies and pilot-scale technology development for disposal of the various types of SNF. The interim dry storage area would consist of passive storage modules designed to safely store the SNF for 40 years. Naval SNF would be examined at a new Expended Core Facility constructed at the ORR prior to being turned over for interim storage management.

The SNF management complex which would be built at the ORR under the Centralization Alternative would have the same components as that built under the Regionalization Alternative. However, the dry storage component would be about 10 times larger, due to the larger SNF inventory that would be transported to the ORR under the Centralization Alternative. The other components of the SNF management complex would be the same general size as those built under the Regionalization Alternative. This is because the inventories of new uncanned fuel which would be sent to the ORR under the Centralization and Regionalization Alternatives would be very similar. Additionally, the major portion of the potential radiological and chemical releases and waste generation rates are associated with these components and would not be significantly different for the Regionalization Alternative. Therefore, this alternative is used as the basis for a semiquantitative comparison with the Regionalization Alternative.

If the ORR is not chosen as the centralization site, all SNF at the ORR would be shipped to the selected centralization site. An exception would be those fuels for which there is no available technology for stabilization to permit safe transport. There is a small quantity of SNF from the Molten Salt Reactor Experiment that is stored in tanks at the ORR. Currently, technology to stabilize this SNF for transport does not exist. Under this alternative, if ORR were to ship SNF to the SRS, this Molten Salt Reactor Experiment SNF would continue to be stored at the ORR until it could be stabilized for safe shipment.

Based on the projected schedule for operation of additional centralized SNF storage facilities, the option for acquiring dry storage facilities at the ORR would be maintained to ensure storage facilities at the ORR would be maintained to ensure continued High Flux Isotope Reactor operation (Brown 1994a; Hoel 1994).

3.2 Comparison of Alternatives

Table 3.2-1 shows a comparison of the alternatives. The Regionalization Alternative column does not include the requirements of the Naval Expended Core Facility, although this facility may be constructed at the site under this alternative. The Centralization Alternative column does include the requirements of the Naval Expended Core Facility, which are presented in Volume 1, Appendix D, since this facility will be built at the site under this alternative.

Table 3.2-1. Comparison of alternatives at the Oak Ridge Reservation.

Parameter	Regionalization Subalternative B at ORR	Centralization Option D[a]
Land for new facilities (acres)	90	120
Site area (acres)	34,667	34,667
Percent of site area	0.26	0.35
SNF-related employment[b]	556	1,118
Baseline site employment	17,082	17,082
Percent of baseline site employment	3.3	6.5
Estimated maximum latent cancer fatalities in 80-km population per year, SNF management operations[c]	2.5 x 10-3	2.5 x 10-3
Estimated cancer fatalities in 80-km population per year, other site operations	2.7 x 10-2	2.7 x 10-2
Estimated probability of cancer fatalities in MEI per year, SNF management operations[c]	3.1 x 10-6	3.1 x 10-6
Estimated probability of cancer fatalities in MEI per year, other site operations	9.2 x 10-6	9.2 x 10-6
Estimated probability of cancer fatality in average worker per year, SNF management operations[c]	1.6 x 10-5	1.6 x 10-5
Estimated probability of cancer fatality in average worker per year, other site operations	1.1x 10-6	1.1x 10-6
Water use (million gallons) per year, SNF management	3.6	6.1
Baseline water use (million gallons) per year, site operations	6,680	6,680
Percent of baseline site water use	0.05	0.09

Electricity use (megawatt-hours) per year, SNF management	23,000	33,000

Table 3.2-1. (continued).

Parameter	Regionalization Subalternative B at ORR	Centralization Option D[a]
Baseline electricity use (megawatt-hours) per year, site operations	1,000,000	1,000,000
Percent of baseline site electricity use	2.30	3.30
Sewage discharge (million gallons) per year, SNF management	3.6	6.1
Baseline sewage discharge (million gallons) per year, site operations	200	200
Percent of baseline site sewage discharge	1.8	3.1
High-level waste (cubic meters) per year, SNF management	0	0
Transuranic waste (cubic meters), SNF management	16	16
Mixed waste (cubic meters), SNF management	0	0
Low-level waste (cubic meters), SNF management	203	628
Estimated maximum cancer fatalities in 80-km population from maximum risk accident[d]	2.1×10^{-2}	
Frequency of occurrence (number per year)[d]	1.6×10^{-1}	
Estimated maximum risk of cancer fatalities in 80-km population maximum risk accident (cancer fatalities per year)[d]	3.4×10^{-3}	
Estimated maximum worker cancer fatalities from maximum risk accident[d]	1.9×10^{-3}	
Frequency of occurrence (number per year)[d]	1.0×10^{-4}	
Estimated maximum risk of worker cancer fatalities from maximum accident (latent cancer fatalities per year)[d]	1.9×10^{-7}	

a. Centralization Option includes the Naval Expended Core Facility (ECF) results from Volume 1, Appendix D. Centralization without ECF would be the same as for Regionalization.
b. Annual average SNF direct construction and operation jobs over the 10-year period 1995 to 2005.
c. Excludes baseline site operations.
d. Centralization Option is the same as the Regionalization Option for the SNF Management Facility and does not include the Naval Expended Core Facility accident analyses results from Volume 1, Appendix D.

4.0 AFFECTED ENVIRONMENT

4.1 Overview

This chapter describes the existing environmental conditions in areas potentially affected by a programmatic decision to site spent nuclear fuel (SNF) facilities at the Oak Ridge Reservation (ORR) under the Centralization and Regionalization alternatives. Topics were selected for analysis based upon their potential to be affected by these alternatives. Each topic is addressed in the detail necessary to serve as a baseline for assessment of potential environmental consequences in Chapter 5.

4.2 Land Use

The ORR occupies an area of approximately 34,667 acres (140 square kilometers) in eastern Tennessee, in a predominantly rural area about 25 miles (40 kilometers) west of Knoxville. The ORR, which is bordered on the southeast and southwest by the Clinch River, is within the jurisdictional boundaries of the City of Oak Ridge, and also lies within Roane and Anderson Counties (MMES 1989).

The ORR consists of three plants located on three separate sites: the Y-12 Plant (1.3 square miles or 3.4 square kilometers); the Oak Ridge National Laboratory (ORNL) (1.8 square miles or 4.7 square kilometers); and the K-25 Site (1.1 square miles or 2.8 square kilometers) (MMES 1989).

Land use activities at the ORR have historically occurred within the boundaries of the three main plant sites. However, more recently, other ORR lands have also begun to be used. ORR land was first utilized for waste storage in the mid-1940s and for environmental research in the 1950s. A forestry management program was initiated in 1964, and the first comprehensive forest management program was released in 1965. The ORR has been used by research institutions, universities, and government agencies as a site for the study of terrestrial ecology, aquatic ecology, forestry, and agriculture. In 1980, Department of Energy (DOE) designated approximately 21 square miles (54 square kilometers) of undeveloped ORR land as a National Environmental Research Park, which today provides protected land areas for research and education in the environmental sciences (MMES 1989).

Land use outside the three main plant sites falls into seven general categories: multi-purpose research and development; support services; waste management; environmental restoration; natural areas; public recreational park; and national environmental research park (Figure 4.2-1). Approximately 58 percent of the land on the ORR (20,051 acres or 31 square miles) can be classified as undeveloped due to its current land use designation (MMES 1994a).

Land uses bordering the ORR are primarily forest and agricultural. Residential and commercial are the only other significant uses of land in the vicinity, and occur along the northeast and northwest boundary of the ORR in the City of Oak Ridge. The land areas bordering the ORR comprise woodlands (mostly hardwood forests), small farms, and rural residences. Commercial forestry and agriculture account for approximately 76 percent of the total land use in this region (MMES 1994a).

The entire ORR has been placed under the forestry, agriculture, industry, and research zoning classification by the City of Oak Ridge, although this designation does not bind DOE land use decisions on the site. DOE land use plans applicable to the ORR include the Oak Ridge Reservation Site Development and Facilities Utilization Plan, issued in 1989 and updated in 1990; the City of Oak Ridge Comprehensive Plan and Zoning Ordinance, issued in 1985 and updated in 1988; and the Resource Management Plan for the U.S. DOE Oak Ridge Reservation, first issued in 1984.

The region surrounding the ORR has numerous local, state, and national public recreation areas (Figure 4.2-2). Federal outdoor recreation facilities include the Great Smoky Mountains National Park; the Cherokee National Forest; the Cumberland Gap National Historic Park; the Big South Fork National River and Recreation Area; and the Obed Wild and Scenic River (MMES 1994a). State parks near the ORR site include the Frozen Head State Natural Area; the Big Ridge State Park; the Cove Lake State Park; the Fall Creek Falls State Park; the Pickett State Rustic Park; the Panther Creek State Park; and the Hiwassee State Scenic River (MMES 1994a).

Figure 4.2-1. Generalized land use at the Oak Ridge Reservation. Figure 4.2-2. Recreation areas in the vicinity of the Oak Ridge Reservation.

Several lakes exist within the ORR surrounding region, offering year-round recreational activities such as fishing and boating. Wildlife management areas that allow in-season hunting include the Big South Fork National River and Recreation Area, Catoosa Wildlife Management Area, Chuck Swan Wildlife Management Area, and the ORR (MMES 1994a).

Numerous locally funded recreational areas exist near the ORR, the closest being in the City of Oak Ridge. The City of Oak Ridge has 2 golf courses, 11 athletic fields, 36 tennis courts, 12 playground areas, and a public outdoor swimming pool (MMES 1994a).

Clark Center Recreational Park, located on the ORR, is a 90-acre (0.36-square-kilometer) recreational area that is open to the public. The park consists of three shelters, a boat ramp, two softball fields, a swimming area, and a paved access road. It is located approximately 2 miles (3.2 kilometers) south of the Y-12 Plant (MMES 1994a).

The ORR is a controlled area with public access limited to through traffic on Tennessee State Routes 95, 58, 62, 162, and 170 (MMES 1991b).

The site proposed for SNF activities is located within the West Bear Creek Valley Area, located in the western portion of the ORR site near the site boundary. This area of the ORR is currently in the Natural Areas land use category and is designated for future Waste Management land use (MMES 1994a). The area is designated as a Potential Site for a Future Programmatic Initiative in the most recent ORR Master Plan (MMES 1994a). With the exception of an industrial park, land uses bordering the ORR in the area of West Bear Creek Valley are primarily agricultural farmland and commercial forest, with sparsely located residences (MMES 1994a).

The industrial park located just to the south of the proposed SNF management facility on Bear Creek Road houses two organizations. The Scientific Ecology Group, Inc., employs about 700 to

800 people and is a low-level radioactive waste incinerator who's commercial operation began in 1989. International Technology, Inc., operates a hazardous and radioactive waste geotechnical laboratory and a pilot lab, also on Bear Creek Road. This International Technology, Inc., operates a hazardous and radioactive waste geotechnical laboratory and a pilot lab, also on Bear Creek Road. This International Technology, Inc., facility is an extension of the Knoxville office and employs about 10 people at the facility (IT undated a, undated b; SEG undated).

There are no onsite areas that are subject to Native American Treaty rights or contain any prime or unique farmland.

4.3 Socioeconomics

4.3.1 Region of Influence

The socioeconomic information presented in this Programmatic Environmental Impact Statement covers the baseline conditions in the Region of Influence. The Region of Influence is defined as the region in which the principal direct and indirect socioeconomic effects of actions at the ORR are likely to occur and are expected to be of consequence for local jurisdictions. The Region of Influence includes the current residential distribution of the DOE and contractor personnel employed by the ORR, the probable location of offsite contractor operations, and the probable location of labor and capital supporting indirect economic activity linked to the ORR. The Region of Influence includes the counties where 92 percent of DOE and contractor personnel employed by ORR reside. The Region of Influence includes the counties of Anderson, where 34 percent of ORR personnel reside, Knox (36 percent), Roane (16 percent), and Loudon (6 percent) (Truex 1991 [Table J]).

4.3.2 Regional Economic Activity and Population

Regional economic linkage supporting production activity at the ORR occurs primarily with Anderson, Knox, and Roane counties, where most of the supporting contractors offsite and labor and capital supporting indirect economic activity linked to the ORR are located.

4.3.2.1 Anderson County. Most of the industrial and commercial development, dominated by

energy-related companies specializing in manufacturing and research and development in support of the ORR, has occurred in the City of Oak Ridge in Anderson County and Roane County.

The major employment sectors in Anderson County in 1990 were services, manufacturing, government, and retail trade. As a percentage of Anderson County wage and salary employment, the service and manufacturing sector each accounted for 30 percent, the government sector 13 percent, and retail trade 11 percent. The number of employed persons in Anderson County in 1990 was 39,596. Jobs in Anderson County have increased 3 percent annually between 1980 and 1990, and are projected to continue to increase at an average rate of less than 1 percent annually for the next several years (U.S. Department of Commerce 1993). Since 1988, the unemployment level for Anderson County has remained below the national unemployment rate. The unemployment rate reached a low of 4.4 percent in 1990 and has slowly increased to 5.6 percent in 1992 (Anderson County 1993; Department of Economic and Community Development Industrial Development Division 1993).

Approximately 40 percent of the Anderson County population resides in the City of Oak Ridge, with an additional 42 percent in rural areas, and the remaining 18 percent in other municipalities in Anderson County (Anderson County 1993). Between 1980 and 1990, the population in Anderson County increased by over 1 percent from 67,500 to 68,250 persons (0.10 percent annually). The population in Anderson County is projected to continue to grow at an average rate of less than 1 percent annually over the next several years, reaching 76,100 persons by 2004 (U.S. Department of Commerce 1993).

4.3.2.2 Knox County. In Knox County, the major employment sectors in 1990 were service,

manufacturing, retail trade, and government. As a percentage of Knox County wage and salary employment, the service sector accounted for approximately 27 percent, retail trade 20 percent, manufacturing 12 percent, and government 17 percent. The total number of persons employed in Knox County in 1990 was 215,948. Jobs have increased 2 percent annually between 1980 and 1990, and are projected to continue to grow at an average rate of less than 1 percent annually for the next several years (U.S. Department of Commerce 1993). The unemployment rate for Knox County was 4.6 percent in 1992 (Department of Economic and Community Development Industrial Development Division 1992).

Between 1980 and 1990, the population in Knox County increased 5 percent from 319,700 to 335,750. The population in Knox County is projected to continue to increase at an average rate of less than 1 percent annually for the next several years, reaching 377,130 persons by 2004 (U.S. Department of Commerce 1993).

4.3.2.3 Roane County. Development that has occurred in Roane County has been

predominantly residential. In Roane County, the major employment sectors in 1990 were retail trade, manufacturing, services, and government. As a percentage of wage and salary employment in Roane County, retail trade accounted for approximately 26 percent, manufacturing 24 percent, services 22 percent, and government 15 percent. The total number of persons employed in Roane County in 1990 was 24,640. Jobs have increased less than 1 percent annually between 1980 and 1990, and are projected to continue to increase at an average rate of less than 1 percent annually for the next several years (U.S. Department of Commerce 1993). The unemployment rate for Roane County was 6.8 percent in 1992 (East Tennessee Development District 1993).

Between 1980 and 1990, the population in Roane County decreased 2.5 percent, from 48,430 to 47,230. The population in Roane County is projected to increase at an average rate of less than 1 percent annually for the next several years, reaching 52,670 persons by 2004.

4.3.2.4 Loudon County. Total employment in Loudon County in 1990 was 12,560 persons. In

1990, the farming sector accounted for a considerably larger percentage, while the services and government sector accounted for a smaller percentage of total jobs than in Anderson, Knox, and Roane counties (U.S. Department of Commerce 1993). The unemployment rate for Loudon County was 6.7 percent in 1992, dropping from 7.2 percent in 1991 due to increase in construction and mining jobs (East Tennessee Development District 1993).

The population of Loudon County increased by 1 percent annually, from 28,700 in 1980 to 31,300 in 1990. The population of Loudon County is projected to increase at an average rate of less than 1 percent annually for the next several years, reaching 32,900 persons by 2004 (U.S. Department of Commerce 1993).

4.3.2.5 Oak Ridge Reservation. The employment level at the ORR in 1994 was 18,200

persons (Truex 1995). In 1993, there were approximately three full-time-equivalent employment positions involved in SNF operations on the ORR (Brown 1994b). Employment levels are expected to decrease to 16,980 by the year 1999 and are projected to remain constant through the year 2004 (Fritts 1994).

4.3.2.6 Aggregate Regional Economic and Demographic Baseline. For the purposes of establishing a regional baseline to compare potential impacts for the programmatic analyses in Section 5.3, regional economic and demographic data for the four-county Region of Influence were aggregated to form one region (Table 4.3-1).

The total population of the Region of Influence, shown in Table 4.3-1, is projected to be 489,230 persons in 1995, and is projected to grow at an annual average rate of less than 1 percent, reaching 538,820 persons in 2004. The labor force of the Region of Influence is also projected to grow at an annual average rate of less than 1 percent, growing to 360,000 persons in 2004. The total employment in the Region of Influence is projected to grow at an annual average rate of approximately 1 percent, growing from 292,700 jobs in 1995 to 338,070 jobs in 2004.

4.3.3 Public Service, Education and Training, and Housing Infrastructure

4.3.3.1 Police and Fire. ORR fire protection services are provided by the fire departments on the reservation. The ORR fire departments have mutual aid agreements among themselves and with the City of Oak Ridge (MMES 1989).

Twelve city, county, and state law enforcement agencies provide police protection in the Region of Influence. In 1990, the largest law enforcement agency in the four-county Region of Influence was in Knoxville, with 296 sworn officers (FBI 1991). Law enforcement on the ORR is provided by the City of Oak Ridge Police Department. Security enforcement, established to meet the Atomic Energy Act and mission requirements, is provided by the prime management and operations contractor (MMES 1989).

Table 4.3-1. Aggregate regional economic and demographic indicators for ORR. a

Years	Regional employment	Regional labor force	Regional population
1995	311,700	332,000	506,600
1996	315,100	335,700	510,300
1997	318,600	339,400	51,400
1998	322,100	343,100	517,900
1999	325,700	346,900	521,700
2000	329,300	350,700	525,500
2001	331,500	353,000	528,800
2002	333,700	355,400	532,100
2003	335,900	357,700	535,500
2004	338,000	360,000	538,800
2005	340,300	362,400	542,200
Average Annual Growth Rate	0.9%	0.9%	0.7%

a. Sources: U.S. Department of Commerce 1993; East Tennessee Development District 1993.

Note: Aggregate region includes the Roane, Anderson, Loudon and Knox Counties. Labor force projection developed for this study.

4.3.3.2 Education and Training. Four school districts, Anderson, Knox, Loudon, and Roane, provide public education services in the Region of Influence. In 1990, the four school districts had an average daily membership of 66,510 students. Knox County had the highest average daily membership of 50,324 students (Tennessee Department of Education 1992).

4.3.3.3 Housing. Between 1980 and 1990, the number of housing units in the Region of

Influence increased 14 percent from 181,299 to 206,234. In 1980 and 1990, the homeowner vacancy rates in the Region of Influence averaged 1.4 and 1.5 percent, respectively (Census 1982, 1991).

Housing additions in the Region of Influence peaked at 3,882 units in 1990, but declined to 3,662 in 1991. In 1992, however, housing additions increased to a total of 3,880 units (East Tennessee Development District 1993).

4.4 Cultural and Paleontological Resources

4.4.1 Archeological Sites and Historic Structures

For approximately 10,000 years, people have inhabited the ORR site. A cultural resources survey conducted in 1975 did not identify any cultural resources on the proposed site for the SNF management facilities. Therefore, no prehistoric or historic resources are expected to be located on the proposed site for the SNF management facilities (Fielder 1975).

4.4.2 Native American Resources

In the early 1700s, the Overhill Cherokee lived in the area that is now the ORR. The tribe remained in the area until 1838, when it was moved forcibly to Oklahoma under Federal orders (Oakes et al. 1984a). While the Cherokee may retain cultural affiliation with their ancestral home, there are no known Native American resources on the proposed site for the SNF facilities.

4.4.3 Paleontological Resources

The ORR is underlain by nine geologic formations or groups ranging in age from Early Cambrian to Early Mississippian. On the ORR, the only formations known to contain fossils are the Knox Group (which does not usually contain fossils but does contain small coiled gastropods in a limestone bed); the Chickamauga Limestone (which contain many fossils including brachiopods, bryozoans, gastropods, cephalopods, crinoid stems, corals, and trilobites); the Sequatchie Formation (which does not have an abundant supply of fossils in the formation, but does contain large brachiopods, colonial corals, and bryozoans within several thin beds of gray limestone); the Rockwood Formation (which contains crinoid stem fossils in the upper half of the formation); and the Fort Payne Chert, which contains many casts of crinoid stems (McMaster 1988). No unusual paleontological remains from the ORR were identified.

4.5 Aesthetics and Scenic Resources

Visual or scenic resources comprise the natural and man-made features that give a particular environment its aesthetic qualities. These features form the overall impression that a viewer receives of an area or its landscape character. Visual sensitivity is assessed by considering the activities, awareness, and expectations of the public within a given area. High visual sensitivity exists when a view is rare, unique, or in other ways special to viewers. Medium visual sensitivity exists when a view is similar to others in the area or is of secondary importance relative to other significant aspects of the area. Low visual sensitivity exists when a view has little value to viewers and an intrusion or alteration of that view would have no impact on viewers.

Scenic resources at the ORR and the surrounding area are set in a landscape of heavily forested,

predominantly parallel ridges with steep slopes interspersed with relatively flat valleys, known physiographically as the Ridge and Valley Province. Due to the rolling topography at the ORR, approximately 62 percent of the reservation is located on slopes of less than 14 percent (MMES 1994a).
The reservation is framed by the Clinch River at the west, south, and eastern boundary, and by Poplar Creek to the north. The vegetation present at the reservation is primarily a mixture of deciduous and coniferous forest covering approximately 80 percent of the site (MMES 1989). Roads providing public access to the interior of the site include State Routes 95 and 58, along with Bethel Valley Road (Figure 4.2-1).

The location of the proposed SNF management facilities, under the Centralization Alternative, is set along the north side of Bear Creek Road west of State Route 95, between the extension of Blair Road and State Route 95, at the western end of the reservation. The public has access to Bear Creek Road west of State Route 95. As a result, the entrance to the site will be visible to traffic on Bear Creek Road (MMES 1994a). The proposed facilities would consist of 90 acres (0.36 square kilometer), 85 of which would be located within security fencing. The facility would have the appearance of industrial buildings ranging in height from one to three stories. The site would receive and unload up to one truck shipment per day, or a total of 5,500 truck shipments over the 40-year operation period. The site would be set on the south side of Pine Ridge midway between the top of the ridge, with elevations ranging between 900 and 1,100 feet (274 and 335 meters), and Bear Creek Valley, with an elevation of approximately 700 feet (213 meters) (TVA 1987). Chestnut Ridge, located south of Pine Ridge on the reservation, faces the site.

Under the Regionalization Alternative, the location of the proposed SNF facility would remain the same but would be reduced in area and extent. Operation of the facilities would also be reduced, resulting in the receipt of fewer truck shipments over the 40-year operation period.

The viewshed surrounding the ORR consists mainly of sparsely populated rural land. The City of Oak Ridge, along the northeast portion of the site, is the only adjacent urban area. Views of DOE facilities from areas surrounding the reservation include those from public roadways such as Interstates 40 and 75, U.S. Route 70, and State Routes 62, 162, and 95. The reservation can also be viewed from the south bluffs along the Clinch River. The Great Smoky Mountains National Park and the Blue Ridge Mountains are approximately 70 miles southeast of the ORR and are generally not visible from the reservation (MMES 1989). In general, views are limited by the rolling terrain, heavily forested vegetation, and hazy atmospheric conditions.

The developed areas of the ORR could generally be classified as having low visual sensitivity. The remainder of the site ranges from low to moderate visual sensitivity. Of the jurisdictions that may be affected by the construction and operation of the proposed SNF facilities, only the City of Oak Ridge in its Comprehensive Plan has provided policies that promote elements of scenic resource enhancement and preservation through streetscape design, landscaping, lighting, and signage improvements at entrances to the urban area and the city center. One entrance to the urban area that promotes scenic resource enhancement and preservation is Illinois Avenue, crossing the northeast portion of the ORR (City of Oak Ridge 1989).

4.6 Geologic Resources

This section provides a general description of the geology, soils, geologic resources, and seismic, volcanic, and other geologic hazards at the ORR and surrounding area. This section also describes any existing impacts to the geology and geologic resources resulting from past and present human activities at the ORR.

4.6.1 General Geology

As shown in Figure 4.6-1, the ORR lies entirely within the western portion of the Valley and Ridge Province, near the boundary with the Cumberland Plateau. The Valley and Ridge Province, a zone of folded and faulted sedimentary rocks in the Appalachian mountain belt, is characterized by numerous linear ridges and valleys that trend approximately southwest-northeast as shown on Figure 4.6-2. The rocks of the Valley and Ridge Province in eastern Tennessee are Early Cambrian to Early Mississippian in age. A stratigraphic column for the ORR southeast of East Fork Ridge (south of Interstate 95) is shown on Figure 4.6-3. A generalized geologic map of the ORR is shown on Figure 4.6-2. Most of the ORR is underlain by the Rome Formation and Conasauga, Knox, and Chickamauga Groups, sedimentary rocks of Cambrian and Ordovician age (Hatcher et al. 1992). A geologic cross-section of the ORR is shown on Figure 4.6-4.

The Rome Formation consists of interbedded sandstone, siltstone, and shale. The base of the Rome is not exposed in the Oak Ridge area, but consideration of regional structural trends suggests that the Rome Formation is in fault contact with younger rocks. On the Copper Creek and Whiteoak Mountain thrust sheets the Rome is 120-180 meters (390-590 feet) thick, and on the Kingston thrust sheet it is over 450 meters (1,500 feet) thick (Hatcher et al. 1992). Thrust sheets carry the name of the fault at their front, or northwest edge. Faults are shown on Figure 4.6-4. The transition between the sandstones of the Rome Formation and the overlying Pumpkin Valley Shale of the Conasauga Group occurs rather abruptly, as the more resistant sandstones grade into the less resistant shales.

Figure 4.6-1. Generalized map of the southern Appalachian geologic provinces showing the location of the Oak Ridge Reservation.
Figure 4.6-2. Geologic map of the Oak Ridge Reservation. Figure 4.6-3. Stratigraphy of the ORR on the Whiteoak Mountain and Copper Creek Thrust Sheets. Figure 4.6-4. Generalized geologic profile beneath the Oak Ridge Reservation.

The formations of the Middle to Upper Cambrian Conasauga Group are primarily limy shales interlayered with shales, limestones, and siltstones. At the ORR, the Conasauga Group is divided into six units (see Figure 4.6-3). Approximately 450 meters (1,500 feet) of the Conasauga Group is exposed at the ORR. The transition from the Conasauga Group to the overlying Knox Group is gradational, with the dominant rock type shifting from shale and dolomitic limestones in the Conasauga Group to dolomites with occasional limestones in the Knox Group.

At the ORR, as in the rest of eastern Tennessee, the Upper Cambrian to Lower Ordovician Knox Group is divided into five formations, which are shown on Figure 4.6-3. The Knox Group is approximately 914 meters (3,000 feet) thick on the ORR and consists primarily of thick beds of silty dolomite (Hatcher et al. 1992). Above the Knox Group is the Middle to Upper Ordovician Chickamauga Group. See Figure 4.6-3 for the units that comprise the Chickamauga on the Whiteoak Mountain thrust sheet.

Surface relief at the ORR typically ranges from a ridge crest to valley floor relief of 30 to 69 meters (100 to 225 feet) (Lee and Ketelle 1987). Surface elevations on the ORR range from a maximum of 413 meters (1,356 feet) National Geodetic Vertical Datum at the crest of Melton Hill (see Figure 2.1-2) to a minimum of 226 meters (740 feet) National Geodetic Vertical Datum near Mile 10 on the Clinch River (Boyle et al. 1982). A series of crests and ridges that trend northeast and southwest make up the ORR (Figure 4.6-2). In general, the crests or ridges are composed of resistant sandstone or dolomite beds. Limestone and shale generally form the ridge flanks and valley bottoms.

Sinkholes, large springs, caves, and other karst features are common in the Knox Group, and those parts of the ORR underlain by limestones and dolomites (certain units in the Conasauga, Knox, and Chickamauga Groups) are for the most part classified as karst terranes. In a karst terrane there is very little surface drainage because of the diversion of surface waters to subterranean (underground) flow routes. These subterranean routes are caves and other enlarged openings that have formed through dissolution of the carbonate rock. Four major karst zones exist at the ORR that appear to be related to distinct stratigraphic horizons (Ketelle 1982). These four karst zones all occur in the Knox Group, specifically in the Copper Ridge Dolomite, near the base of the Chepultepec Dolomite, near the top of the Chepultepec Dolomite, and in the Kingsport Formation (Ketelle 1982). Karst development is also present to varying degrees in the carbonate rocks of the Conasauga Group, most notably in the Maynardville Limestone. In Bear Creek Valley, karst development in the Maynardville Limestone causes variations in discharge along Bear Creek as the surface water and groundwater components vary in dominance (Lee et al. 1988). Bear Creek Valley is underlain by calcareous shale and limestone of the Conasauga Group (Bailey and Lee 1991). Although no site-specific geologic characterization has been conducted at the West Bear Creek Valley site, it appears the proposed SNF management facility is located over the lower Conasauga Group strata not normally characterized by karst development.

The soils occurring in the ORR are predominantly clay, although chert and quartz are also present. Soils developed in the Conasauga are clay. Hatcher et al. (1992) provides detailed information on soils. Many of the soils belong to the broad group of Ultisols, which are reddish or yellowish, moderately acidic soils. Entisols, which are thin surface soils over bedrock that show little development of soil horizons, are found locally in steeply sloping areas. In addition, small areas of inceptisols are found in alluvial areas adjacent to streams (Boyle et al. 1982). These are young soils, also with minimal horizon development. Soils on the ORR tend to retain moisture and are typically 90 percent saturated below a depth of 3 meters (10 feet) (Ketelle and Huff 1984). Depths of soil profiles on the ORR vary from 15 centimeters (6 inches) on slopes to 18 meters (60 feet) over dolomites in the Knox Group (Boyle et al. 1982).

4.6.2 Geologic Resources

The known resources of the geologic units exposed on the ORR are limited to industrial minerals, including quarry rock and clay. These industrial minerals are of low unit value and can be found elsewhere. Quarry rock has been mined at several major locations throughout ORR, but no quarries are currently in operation (Oakes et al. 1984b).

There has been extensive seismic testing by private companies along roads traversing the ORR to explore for deep accumulations of oil and gas. Land has been leased by major oil companies west and northwest of K-25 off the ORR; no exploratory wells have been drilled and the status of oil and gas resources underlying the ORR is unknown at this time (Oakes et al. 1984b).

4.6.3 Seismic and Volcanic Hazards

There is no evidence that there has been volcanic activity in the vicinity of the ORR for more than 1 million years.

4.6.3.1 Historical Seismic Activities. From 1811 to 1975, only five major earthquakes or

earthquake series have affected the ORR area. These are the New Madrid, Missouri, earthquake series, and the Charleston, South Carolina; Knoxville, Tennessee; Strawberry Plains, Tennessee; and Kingston, Tennessee earthquakes. The New Madrid earthquake series of December 1811 to February 1812 produced maximum Modified Mercalli Intensity disturbances of V to VI in the ORR area. A Modified Mercalli Intensity V earthquake is felt by everyone. Typical damage includes some dishes, windows, etc. being broken, a few instances of cracked plaster, and unstable objects being overturned. A Modified Mercalli Intensity VI earthquake is also felt by all, and many become frightened and run outdoors. Typical damage includes some heavy furniture moved and a few instances of fallen plaster or damaged chimneys. A Modified Mercalli Intensity of VI is approximately equal to a Richter Magnitude 4.7 (Griggs and Gilchrist 1977).

The 1844 Knoxville earthquake, which occurred approximately 40 kilometers (25 miles) from the ORR, had an epicenter shaking of Modified Mercalli Intensity VI. The Charleston earthquake of 1886 had a Modified Mercalli Intensity of V to VI at the ORR, as did the 1913 Strawberry Plains earthquake. The 1930 Kingston earthquake, 8 kilometers (5 miles) northwest of the ORR, had an epicenter shaking of Modified Mercalli Intensity V (Boyle et al. 1982). When intensities are reported at epicenters, they would have been less at the ORR, as intensities diminish with distance.

A Modified Mercalli Intensity VII earthquake does not typically cause severe damage, but rather causes breaking of weak chimneys at the roof line, cracks in masonry, and the falling of plaster, loose bricks, and stones. No Modified Mercalli Intensity VII earthquakes have been recorded at the ORR during the 165-year period from 1811 to 1975. Earthquakes with a Modified Mercalli Intensity of VII generally occur one order of magnitude less frequently than earthquakes with a Modified Mercalli Intensity of V to VI. Seismic records indicate that the ORR is located in a region of moderate seismic activity having an average of one to two earthquakes per year, with seismic activity occurring in bursts followed by long periods of no activity. No deformation of recent surface deposits has been detected, and seismic shocks from the surrounding, more seismically active areas are dissipated by distance from the epicenters (Boyle et al. 1982).

The underlying structure of the ORR is complex due to the extensive faulting and deformation characteristic of the region. There are three regional thrust faults in the ORR area, the Kingston, Whiteoak Mountain, and Copper Creek Faults (see Figure 4.6-4). All three strike to the northeast and dip to the southeast. Latest movement on the faults was Late Pennsylvanian/Early Permian (280 to 290 million years ago); consequently, they are not considered to be capable faults at present (Oakes et al. 1984b). According to 10 CFR Part 100, Appendix A, capable faults include those faults that have exhibited movement at or near the ground surface at least once during the past 35,000 years or movement of a recurring nature within the past 500,000 years.

4.6.3.2 Seismicity Studies. Four seismic studies have been specifically conducted for the

ORR for which the results have been published. Three of these studies have been summarized by Beavers et al. (1982), and were performed by Blume in 1973, Dames and Moore in 1973, and TERA in 1981. The first two studies were directed toward the seismic hazards at the K-25 Site (formerly the Oak Ridge Gaseous Diffusion Plant), and the latter focused on ORNL (Beavers et al. 1982).

These three early studies presented preliminary analysis and conclusions. The fourth study (McGuire et. al. 1992), is a more recent seismic analysis for the entire ORR. DOE Standards 1020 (DOE 1994a) and 1024 (DOE 1992b) summarize the results of recent seismic analyses at DOE sites and show that the peak ground accelerations for the ORR for 500-year, 1,000-year, 2,000-year and 5,000-year seismic events are 0.08g, 0.13g, 0.19g and 0.29g, respectively.

Figure 4.6-5 presents the site specific uniform hazard response spectra for horizontal rock motion which were approved by DOE Headquarter's Office of Nuclear Energy on August 25, 1993 (Benedict 1993). The response spectra noted on Figure 4.6-5 are for top of rock sites.

4.6.3.3 DOE Seismic Design Criteria. DOE Order 5480.28 requires that the Design and

Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards, UCRL-15910 (Kennedy et al. 1990), be used for natural phenomena hazards design and evaluation criteria until a DOE standard is issued. In April 1994, DOE-STD-1020 was issued to replace UCRL-15910.

At the SNF management facility site the categorization of each structure, system and component would be determined in accordance with DOE Standard DOE-STD-1021, Performance Categorization Criteria for Structures, Systems and Components at DOE facilities Subjected to Natural Phenomena Hazards.

A maximum horizontal ground surface acceleration of 0.19g at ORR is estimated to result from an earthquake that could occur once every 2,000 years (DOE, 1994a). The seismic hazard information presented in this EIS is for general seismic hazard comparisons across DOE sites. DOE orders, standards and site specific procedures require that potential seismic hazards for existing and new facilities be evaluated on a facility specific basis.

Figure 4.6-5. Oak Ridge- Site Specific Uniform Hazard Response Spectra for Horizontal Rock Motion 4.7 Air Resources

4.7.1 Climatology

Except where indicated, the information presented in this section is derived from Fitzpatrick 1982 and NOAA 1991.

The ORR site is located within the Great Valley of Tennessee in which the Cumberland Plateau borders to the northwest and the Great Smoky Mountains lie to the southeast. Climate at the ORR is influenced by these terrain features.

The climate and meteorology in the lowlands are generally unlike those that occur in the more mountainous regions of the southeastern United States. Daytime winds are usually southwesterly, while night-time winds are northeasterly, at least during periods of light wind. The elevated ridges of the Cumberland Plateau and Great Smoky Mountains encompassing the valley impede wind speeds to a moderate degree. The Cumberland Plateau retards the drainage of cold air from the northwest into the valley during winter, thus reducing the probability of extremely cold temperatures.
The average daily temperature at the Oak Ridge National Weather Service Station, considered representative of the ORR, was 14.2oC (57.5oF) for the period of record 1961-1990. The average daily temperatures varied from a low of 2.6oC (36.7oF) in January to a high of 24.8oC (76.6oF) in July.

Humidity data are maintained at the Knoxville National Weather Service with a period of record from 1961-1990. Records are reported for humidity readings during the hours 0100, 0700, 1300, and 1900 (local time). The 0700 and 1900 values will be reported here. The mean 0700 relative humidity was 86 percent with the mean monthly maximum of 92 percent occurring in July and August, and the mean monthly minimum of 80 percent occurring during February and March. The mean 1900 relative humidity is 63 percent with the mean monthly maximum of 68 percent occurring in September and December, and the mean monthly minimum of 52 percent occurring in April.

The mean wind speed measured at the Oak Ridge National Weather Service over the period 1969 to 1984 was 2.0 meters per second (4.4 miles per hour) at an average height above ground of about 13 meters (41 feet). At a meteorological tower at the ORR the mean wind speed was 2.1 meters per second (4.7 miles per hour) at about 10 meters (33 feet) above ground level. Wind speeds in the ORR area are influenced by local topographic conditions and are generally higher on top of the ridges than in the valleys.

The wind direction above the ridgetops and within the valleys tends to follow the orientation of the valleys. The prevailing wind direction is from the southwest, with a secondary maximum from the northeast during the winter, spring, and summer months. The situation is reversed in the fall.

Figure 4.7-1 shows 1992 wind roses for the 10- and 60-meter levels of the Y-12 west meteorological tower. The annual 10-meter level on the Y-12 west meteorological tower shows peak wind direction frequencies from the west-southwest, with the secondary peak from the northeast. The annual 60-meter level shows wind direction frequencies from the northeast and a secondary peak from the southwest. Since the valley floor is inclined, cold air will drain down the valley during stable periods. Both wind rose levels show the influence of the topography on the wind direction.

Damaging winds are uncommon in the region. Peak gusts recorded in the Great Valley are generally in the 27- to 31-meter-per-second (60- to 70-mile-per-hour) range for the months of January through July; in the 22- to 27-meter-per-second (50- to 60-mile-per-hour) range for August, September, and December; and in the 16- to 20-meter-per-second (35- to 45-mile-per-hour) range in October and

November. The maximum gust reported in the region was about 37 meters per second (82 miles per hour); it occurred during the month of March at Chattanooga. Knoxville has reported a peak gust of about 33 meters per second (73 miles per hour) and Oak Ridge a gust of about 26 meters per second (59 miles per hour).

Winter is the wettest of the seasons in the ORR area; March and December are the wettest months and October the driest. The annual average precipitation measured at the ORR in Bethel Valley from 1944 through 1964 was 130.9 centimeters (51.5 inches), while the annual average precipitation for the National Weather Service in Oak Ridge from 1961 through 1990 was 137.2 centimeters (54.0 inches). The maximum monthly precipitation was 48.9 centimeters (19.3 inches) in July 1967, while the maximum rainfall in a 24-hour period observed at the Oak Ridge National Weather Service was recorded in August 1960 at 19.0 centimeters (7.5 inches).

Figure 4.7-1. Wind Roses for Y-12 west tower (@ 10 and 60m) for 1992 at ORR.

On average there are about 51 thunderstorm days per year at the Oak Ridge National Weather Service station. The summer thunderstorms, which may be accompanied by strong winds, heavy precipitation, or, less frequently, hail, occur primarily during the late afternoon and evening hours. Summer thunderstorms are attributable primarily to convective activity resulting from solar heating of the ground and generally moist atmospheric conditions. Thunderstorm activity in the winter months is attributable mainly to frontal activity.

The Great Valley of Tennessee is infrequently subject to tornadoes. The western half of the state has experienced three times as many tornadoes as the eastern half, where the ORR is located. The ORR did experience a tornado from a severe thunderstorm on February 21, 1993 (MMES 1993b). The tornado path passed the Y-12 Plant in an east-northeast direction for approximately 21 kilometers (13 miles), ending just north of Knoxville. The wind speeds associated with this tornado ranged from 18 meters per second (40 miles per hour) to nearly 58 meters per second (130 miles per hour), depending on the location along the path (MMES 1993b).

Hurricanes are rarely sustained once they reach as far inland as the Great Valley due to the rapid loss of energy when they are cut off from their source of moisture. The remnants of nine hurricanes that were classified as devastating after crossing the coastline of the United States have traversed the borders of Tennessee in the last 70 years.

Atmospheric dispersion improves as wind speed increases, conditions become more unstable, and the depth of the mixing height increases. The transport and dispersion of airborne material are direct functions of air movement. Transport directions and speeds are governed by the general patterns of air flow (and by the nature of the terrain), whereas the diffusion of airborne material is governed by small-scale, random eddying of the atmosphere (i.e., turbulence). Turbulence is indicated by atmospheric stability classification. Data collected at Y-12 for calendar year 1992 were classified using the vertical temperature difference (i.e., between 60- and 10-meter levels) in accordance with Nuclear Regulatory Commission Regulatory Guide 1.23 (NRC 1986). The atmospheric conditions are unstable (i.e., Stability Classes A through C) approximately 5 percent of the time, neutral (Class D) approximately 43 percent of the time, and stable (Classes E through G) approximately 52 percent of the time at the 10-meter level.

4.7.2 Air Monitoring Networks

This section discusses the air monitoring networks of the ORR. Atmospheric emissions from the ORR facilities are monitored by stack monitors and by a network of ambient air monitoring stations on the perimeter of each major ORR operations area (ORNL, the Y-12 Plant, and K-25 Site), as well as on the ORR perimeter and throughout the surrounding communities.

4.7.2.1 Radiological Monitoring Network. Twelve of the ambient air monitoring stations on the perimeter of the Y-12 Plant routinely monitor total suspended uranium particulates. The ORNL perimeter monitoring network consists of four stations that monitor radiation parameters (i.e., gross alpha, gross beta, iodine, and gamma-emitting radionuclides). Samples of atmospheric tritium are also collected monthly at selected perimeter stations.

4.7.2.2 Nonradiological Monitoring Network. The perimeter ambient air monitoring network for K-25, which was upgraded in 1986, consists of five stations that monitor airborne particulate contaminants such as nickel, lead, and chromium. In 1988, two additional ambient air monitoring stations were installed at the K-25 Site. These stations measure polychlorinated biphenyls, furans, dioxins, and hexachlorobenzene that may accidentally be released due to the Toxic Substance Control Act incinerator (located in the K-25 area).

4.7.3 Air Releases

4.7.3.1 Radiological Emissions. Table 4.7-1 presents the radioactive emissions to the atmosphere from each of the three ORR areas (ORNL, K-25, and Y-12) during 1992.

Table 4.7-1. Radioactive atmospheric emissions (curies/yr) from the ORR during 1992.

Isotope	ORNL	K-25	Y-12
Hydrogen-3 (Tritium	2.14 x 103	0.0 x 100	0.0 x 100
Beryllium-7	8.91 x 10-6	0.0 x 100	0.0 x 100
Potassium-40	0.0 x 100	1.01 x 10-3	0.0 x 100
Cobalt-57	0.0 x 100	0.0 x 100	0.0 x 100
Cobalt-60	2.97 x 10-5	0.0 x 100	0.0 x 100
Bromine-82	1.02 x 10-5	0.0 x 100	0.0 x 100
Krypton-83m	7.32 x 101	0.0 x 100	0.0 x 100
Krypton-85	0.0 x 100	0.0 x 100	0.0 x 100
Krypton-85m	1.73 x 102	0.0 x 100	0.0 x 100
Krypton-87	3.50 x 102	0.0 x 100	0.0 x 100
Krypton-88	4.94 x 102	0.0 x 100	0.0 x 100
Krypton-89	6.27 x 102	0.0 x 100	0.0 x 100
Strontium-90	1.19 x 10-4	0.0 x 100	0.0 x 100
Niobium-95	0.0 x 100	0.0 x 100	0.0 x 100
Technetium-97	0.0 x 100	6.10 x 10-2	0.0 x 100
Ruthenium-106	0.0 x 100	4.36 x 10-4	0.0 x 100
Iodine-129	2.70 x 10-4	0.0 x 100	0.0 x 100
Iodine-131	1.25 x 10-1	0.0 x 100	0.0 x 100
Iodine-132	1.36 x 100	0.0 x 100	0.0 x 100
Iodine-133	6.48 x 10-1	0.0 x 100	0.0 x 100
Iodine-134	2.05 x 10-2	0.0 x 100	0.0 x 100
Iodine-135	1.22 x 100	0.0 x 100	0.0 x 100
Xenon-133	8.81 x 102	0.0 x 100	0.0 x 100
Xenon-133m	2.74 x 10	0.0 x 100	0.0 x 100
Xenon-135	2.82 x 10	0.0 x 100	0.0 x 100
Xenon-135m	1.55 x 102	0.0 x 100	0.0 x 100
Xenon-138	8.50 x 102	0.0 x 100	0.0 x 100
Cesium-134	6.03 x 10-7	0.0 x 100	0.0 x 100
Cesium-137	6.13 x 10-4	8.16 x 10-5	0.0 x 100
Cesium-138	0.0 x 100	0.0 x 100	0.0 x 100
Barium-137	3.84 x 10-4	0.0 x 100	0.0 x 100
Barium-137m	6.13 x 10-4	8.16 x 10-5	0.0 x 100
Barium-140	1.00 x 10-4	0.0 x 100	0.0 x 100
Lanthanum-140	1.39 x 10-6	0.0 x 100	0.0 x 100
Cerium-144	0.0 x 100	1.23 x 10-6	0.0 x 100
Europium-152	1.86 x 10-12	0.0 x 100	0.0 x 100
Europium-154	5.87 x 10-6	0.0 x 100	0.0 x 100
Europium-155	3.02 x 10-6	0.0 x 100	0.0 x 100
Osmium-191	2.27 x 10-2	0.0 x 100	0.0 x 100
Gold-194	0.0 x 100	0.0 x 100	0.0 x 100
Lead-212	1.56 x 100	0.0 x 100	0.0 x 100

Thorium-228	9.52 x 10-6	1.54 x 10-3	0.0 x 100
Thorium-230	6.49 x 10-7	7.41 x 10-4	0.0 x 100
Thorium-232	1.86 x 10-7	2.96 x 10-5	0.0 x 100
Thorium-234	0.0 x 100	0.0 x 100	0.0 x 100
Protactinium-234m	0.0 x 100	4.07 x 10-1	0.0 x 100
Uranium-234	2.24 x 10-5	2.55 x 10-2	4.70 x 10-2
Uranium-235	4.79 x 10-7	1.12 x 10-3	1.49 x 10-3
Uranium-236	0.0 x 100	0.0 x 100	1.86 x 10-4
Uranium-238	7.57 x 10-7	3.74 x 10-2	4.11 x 10-3
Neptunium-237	0.0 x 100	1.10 x 10-4	0.0 x 100
Plutonium-238	7.40 x 10-6	6.02 x 10-4	0.0 x 100
Plutonium-239	2.06 x 10-5	1.12 x 10-4	0.0 x 100
Americium-241	1.37 x 10-5	0.0 x 100	0.0 x 100
Curium-244	2.05 x 10-4	0.0 x 100	0.0 x 100

4.7.3.2 Nonradiological Emissions. Table 4.7-2 presents the nonradiological emissions to the atmosphere from each of the three ORR areas during 1992.

4.7.4 Air Quality

4.7.4.1 Radiological. A summary of ORR airborne radionuclide emissions for 1992 is presented in Table 4.7-1. The GENII environmental transport and dose assessment model was used to calculate the effective dose equivalent resulting from these radionuclide emissions. These results are summarized in Table 4.7-3. The maximum effective dose equivalent at the ORR boundary is 3.3 millirem. This is 33 percent of the corresponding National Emissions Standard for Hazardous Air Pollutants. The collective effective dose equivalents to the estimated population of 910,000 persons within 80 kilometers (50 miles) of the proposed SNF facility is 52 person-rem. This dose is 0.019 percent of the natural background radiation affecting this population. Background radiation doses are presented in Figure 4.7-2.

4.7.4.2 Nonradiological. The ORR is located in Anderson and Roane Counties, in the Eastern Tennessee-Southwestern Virginia Interstate Air Quality Control Region 207. As of 1993, the areas within this Air Quality Control Region were designated as attainment with respect to all National Ambient Air Quality Standards (CFR 1993a).

One Prevention of Significant Deterioration ambient air quality Class I area can be found in the vicinity of ORR. That is the Great Smoky Mountains National Park, located approximately 48 kilometers (30 miles) southeast of ORR. Since the promulgation of the Prevention of Significant Deterioration regulations, no such permits have been required for any emissions source at the ORR.

Ambient air quality within and near the ORR is monitored for total suspended particulates, particulate matter less than 10 microns in diameter (PM10), fluorides, lead, and sulfur dioxide, which was monitored until August 1990 (MMES 1993a). Ambient air quality monitoring data collected at the ORR are summarized in Table 4.7-4.

Table 4.7-2. Nonradiological emissions at ORR (kg/yr).

Pollutant	Y-12	ORNL	K-25
Carbon monoxide	36,807	45,872	12,119
Nitrogen dioxide	648,746	201,090	20,065
Particulates	1,576	5,599	1,137
Sulfur dioxide	268,894	703,419	302
Volatile organic compound	1,582	1,068	1,011
Chlorine	91	b	1,567
Hydrochloric acid	6,959	b	42
Methanol	26,407	b	b
Nitric acid	9,491	30	b
Perchloroethylene	12,245	b	b
Sulfuric acid	2,424	0	130

Hydrogen fluoride	73	b	b
Mercury	0.01	b	b
Trichloroethane	745	b	b

a. Source: MMES (1993a).

b. No source indicated.

Table 4.7-3. Summary of effective dose equivalents to the public from ORR operations during 1992.

	Maximum exposed individual doseb	Collective dose to the population within 80 km of ORR sourcesc
Dose	3.3 mrem	52 person-rem
National Emission Standards for Hazardous Air Pollutants standard	10 mrem per year	--
Percentage of National Emission Standards for Hazardous Air Pollutants	33	--
Natural background dose	295 mrem per year	279,000 person-rem per year
Percentage of natural background dose	1.1	0.019

a. Sources: MMES (1993a); PNL (1988).

b. The maximum boundary dose is to the hypothetical individual who remains in the open continuously during the year at the ORR boundary.

c. Based on estimated population of 910,000 persons within 80 kilometers of the proposed SNF facility site location in 1995.

Figure 4.7-2. Sources of radiation exposure, unrelated to Oak Ridge Reservation operations, to individuals in the vicinity of ORR.

Table 4.7-4. Comparison of baseline concentrations with most stringent applicable regulations and guidelines at the ORR.

Criteria pollutant	Averaging time	Most stringent regulation or guideline (-g/m3)	Maximum(a) background concentration (-g/m3)	Maximum existing site contribution (-g/m3)	Total existing maximum concentration (-g/m3)
Carbon monoxide	8-hour	10,000	b	6.9	6.9
	1-hour	40,000	b	24.1	24.1
Nitrogen dioxide	Annual	100	b	2.1	2.1
Lead	Calendar quarter	1.5	b	c	c
Particulate matter less than 10 microns in diameter	Annual	50	8	4.0d	12.0
	24-hour	150	54	43.9d	97.9
Sulfur dioxide	Annual	80	27	2.3	29.3
	24-hour	365	146	31.8	177.8
	3-hour	1,300	321	80.5	401.5
Total suspended particulatesf	Annual	50	32	4.0	36.0
	24-hour	150	73	43.9	116.9
Hydrogen	30-day	1.2	0.06	c	0.06
Fluoride	7-day	1.6	0.03	c	0.03
Hydrogen fluorides (as fluorides)	24-hour	2.9	b	c	c
	8-hour	3.7	b	c	c

Hazardouse air pollutants					
Chlorine	8-hour	150	b	0	c
Selenium	8-hour	20	b	c	c
Mercury	8-hour	0.5	b	c	c
Chromium	8-hour	5	b	c	c
Chrome	8-hour	5	b	c	c

a. Ambient air quality data (MMES 1992a, 1991a).

b. Not monitored.

c. Not estimated because the potential release is negligible.

d. It is conservatively assumed that data for particulate matter less than 10 microns in diameter (PM10) are total suspended particulates data.

e. State standard.

f. State guideline.

Table 4.7-4 presents the effects of site emissions on local ambient air quality. Concentrations of pollutants obtained from ambient air quality monitoring data are added to pollutant concentrations determined from air dispersion modeling using site-specific emission rates. The resulting sum is used to compare total concentrations to applicable Federal and state criteria pollutant and hazardous/toxic air pollutant guidelines and regulations. All pollutant concentrations of existing emissions at the ORR are below applicable regulations.

4.8 Water Resources

4.8.1 Surface Water

The hydrologic system on the ORR is controlled by the Clinch River (MMES 1994a). The Clinch River flows about 350 miles (560 kilometers) from its headwaters in southwest Virginia, near Tazewell, to its confluence with the Tennessee River at Kingston, Tennessee. Its drainage area is about 4,410 square miles (11,340 square kilometers) (Boyle et al. 1982). All water that drains from the ORR enters the Clinch River and subsequently the Tennessee River.

Flow in the Clinch-Tennessee River system is regulated by multipurpose dams of the Tennessee Valley Authority (TVA). Three dams operated by the TVA control the flow of the Clinch River. Norris Dam, approximately 31 miles (50 kilometers) upstream of the ORR, was constructed to provide flood control and low-flow regulation. Melton Hill Dam, south of the ORNL site, controls the flow of the Clinch River near the ORR. Its primary function is power generation. Flood control is a secondary function. Watts Bar Dam, also used for power generation, is located on the Tennessee River and influences the lower reaches of the Clinch River by creating backwaters that can extend as far upstream as Melton Hill Dam (Oakes et al. 1987).

Heavy precipitation in the area causes localized flooding, primarily in the City of Oak Ridge (MMES 1994a) and along the Clinch River. A flood analysis was prepared by the TVA for the ORR (TVA 1991). This analysis provides flood elevations for flooding events in the Clinch River and major tributaries on the ORR. Flooding events analyzed ranged from the 25-year flood (a flood with a 1 in 25 chance of being equaled or exceeded in any given year) to probable maximum flooding events. Approximate 500-year floodplains (1 in 500 chance in any given year) are shown on Figure 4.8-1. Site-specific surveys should be performed to more accurately determine locations of flooding elevations.

The average discharge from Melton Hill Dam between 1963 and 1979 was 5,300 cubic feet (150 cubic meters) per second (Boyle et al. 1982). The average summer (June-September) discharge for the same period was 4,730 cubic feet (134 cubic meters) per second. However, power is generated at Melton Hill Dam to help meet peak loads and, as a result, flow in the Clinch River is pulsed. Periods of no flow at the dam can be followed by periods of flow of up to 20,000 cubic feet (560 cubic meters) per second. Variations in the flow of the Clinch River affect the flow of the tributaries on the ORR. For example, during peak periods of power generation at Melton Hill Dam, flow from White Oak Creek can be blocked or even reversed. The 1992 minimum monthly release at the Melton Hill Dam occurred in May and was 3.5 billion cubic feet (100 million cubic meters) (MMES 1994a).

The ORR is drained by a network of tributaries of the Clinch River (Figure 4.8-1). A statewide stream classification system based on water quality, water use, and resident aquatic biota designates most streams on the ORR for fish and aquatic life, irrigation, and livestock watering (MMES 1992a). For each designated classification, specific water quality criteria are applied, forming the basis for facility-specific National Pollutant Discharge Elimination System permits. No rivers designated as wild and scenic occur on the ORR.

Stream flow on the ORR varies primarily with seasonal precipitation (MMES 1994a). Precipitation varies throughout the year, with the winter months and July experiencing the highest rainfall. Five-year cycles of wet and dry seasons are also evident. Precipitation is lost through evaporation, vegetation uptake, runoff to streams, and to groundwater recharge through the soil.

The drainage pattern on the ORR is a weakly developed "trellis" pattern (Lee and Ketelle 1987). The majority of the small streams are located in the northeast-southwest-trending valleys. Some streams flow across the ridges through water gaps that may have formed due to the presence of structural features (Golder Associates 1988). Karst topography also affects the appearance of surface drainage patterns, primarily because of the presence of sinkholes in areas underlain by the Knox Group.

Figure 4.8-1. Locations of the Clinch River and tributaries on the Oak Ridge Reservation.

A number of wetlands occur on the ORR (MMES 1994a). Wetlands are surface features periodically saturated with or covered by water, and have hydric soils and hydrophytic plants. With regards to water resources issues, wetlands absorb flood waters and improve groundwater quality. Characteristic wetlands of the ORR region include forested wetlands along creeks, wet meadows and marshes associated with streams and seeps, and emergent communities in shallow embayments and ponds.

The abundance of limestone and dolomite is reflected by the presence of calcium bicarbonate in the surface waters at the ORR. Water hardness is typically moderate, and the concentrations of total dissolved solids normally range between 100 and 250 milligrams per liter (Rogers et al. 1988).

Measurements of surface water quality and flow are made at a number of sampling stations on and around the ORR. Reference surface waters, ORR surface waters receiving effluents, off-reservation surface waters, and effluents are all sampled and analyzed as part of the surface water monitoring program. Water samples are collected and analyzed for radiological and nonradiological content, and the results are reported yearly in publicly available environmental reports (e.g., MMES 1993a; 1992a; 1991a).

Although bedrock characteristics differ somewhat among the watersheds of these streams, most of the observed differences in water quality are attributed to different contaminant loadings (Rogers et al. 1988). Both wastewater discharges and the groundwater transport of contaminants from waste disposal sites affect water quality in ORR streams. Consequently, a number of surface streams have been contaminated by activities at the ORR (DOE 1992c). In the past, contaminants have been directly released to surface waters on the ORR. Indirect releases via shallow groundwater discharge to surface water streams have occurred in the past and continue to date. For example, activities at the ORNL have contaminated reaches of the White Oak Creek system and Melton Branch with radionuclides, metals, and other hazardous chemicals. The stream channel of Upper East Fork Poplar Creek in the Y-12 Plant area has been contaminated from past activities at the Y-12 Plant. Activities at the Y-12 Plant have also contaminated surface water and groundwater in the Bear Creek Valley with nitrates, volatile organics, radionuclides, and metals beyond the ORR boundary. Operations at the Y-12 Plant have also contaminated Lower East Fork Poplar Creek beyond the ORR boundary with mercury, other metals, organics, and radionuclides. Ultimately, contaminants from all these streams have been discharged to the Clinch River, where sediment contamination is a primary concern.

All effluent discharges to streams are required to meet specified National Pollution Discharge Elimination System permit limits (MMES 1994a). For example, the quality of water in East Fork Poplar Creek partially reflects the influence of the Y-12 Plant and the City of Oak Ridge municipal wastewater treatment facility. Each of the ORR installations has a National Pollution Discharge Elimination System permit. In 1992, more than 400 National Pollution Discharge Elimination System stations were sampled, requiring more than 65,000 water analyses. Significant reductions in the number of noncompliances for the ORR between 1991 to 1992 were engineered especially with respect to the Y-12 Plant. The K-25 Site was in 99.9 percent compliance with discharge limits. The Y-12 Plant was in 99.5 percent compliance with discharge limits. The ORNL was in 99 percent compliance with discharge limits. Table 4.8-1 lists the National Pollution Discharge Elimination System noncompliances by installation **and discharge point.** At the Y-12 Plant, ORNL, and the K-25 Site, radiological effluents were well within limits at all effluent monitoring locations (MMES 1993a).

Water quality in the Clinch River is affected by ORR activities, by contaminants introduced upstream from the ORR, and by flow regulation at the Tennessee Valley Authority dams. Stream impoundment has resulted in a rise in water temperatures, sediment retention, and contaminant adsorption. Several institutions routinely monitor water quality in the Clinch River. Both the Tennessee Valley Authority and the U.S. Geological Survey monitor just below Melton Hill Dam. The Tennessee Department of Environment and Conservation maintains a monitoring station on the Clinch River about 2 miles (3.2 kilometers) below the mouth of Poplar Creek and the K-25 Site (Rogers et al. 1988).

The Clinch River supplies most of the water to the ORR, the City of Oak Ridge, and other cities along the river (MMES 1994a). Major surface water uses in the Oak Ridge area include withdrawals for

Table 4.8-1. 1992 National Pollutant Discharge Elimination System noncompliance at the ORR.

Installation	Discharge point	Parameter	Percent compliance	Number of samples
Y-12	302 (Rogers Quarry)	pH	99	53
	501 (Central Pollution Control Facility [CPCF-1])	Total toxic organics	91	23
	502 (West End Treatment Facility)	Total suspended solids	98	54
	503 (Steam Plant Wastewater Treatment Facility)	Iron, total	99	158
		Oil and grease	99	157
	Category IV outfalls (untreated process wastewaters)	pH	95	107
	506 (9204-3 sump pump oil)	Oil and grease	98	53
		pH	98	53
	512 (Groundwater Treatment Facility)	Polychlorinated biphenyls	97	37
	Creek Outfalls	Visual	not applicable	22a
ORNL	X01 (Sewage Treatment Plant)	Oil and grease	99	157
		Total suspended solids	96	157
	X02 (Coal Yard Runoff Treatment Facility)	Oil and grease	94	34
	Category I outfalls	Oil and grease	33	3
	Category II outfalls	Oil and grease	87	166
		Total suspended solids	91	166
	Cooling systems	Chlorine, total residual	98	45
		Copper, total	98	45
		Zinc, total	98	45
K-25	001 (K-1700 discharge)	Aluminum	96	not available (4)b
		Oil and grease	99	not available (1)b
	005 (K-1203 sanitary treatment facility)	Chlorine, residual	99	not available (1)b
		Fecal coliform, No./100 milliliter	99	not available (2)b
		Settleable solids, milliliter/liter	99	not available (1)b

006 (K-1007-B holding pond)	Chemical Oxygen Demand	99	not available (1)b
007 (K-901-A holding pond)	Chromium, total	98	not available (1)b
	Suspended solids	98	not available (2)b
	Dissolved oxygen	98	not available (6)b
Storm drain	Unpermitted discharge	not applicable	4b

a. Source: MMES (1993a).

b. Number of noncompliances.

industrial and public water supplies, commercial and recreational navigation, and other recreational activities such as fishing, boating, and swimming. Five public water supplies are located downstream of the ORR (MMES 1994a). The two nearest are the K-25 Site water treatment plant and the Kingston water treatment plant. These are located 2.5 miles (4 kilometers) above and 21 miles (34 kilometers) below the mouth of Poplar Creek, respectively.

4.8.2 Groundwater

Groundwater beneath the ORR is heavily influenced by the site geologic structure (Solomon et al. 1992). Geologic units of the ORR are assigned to two broad hydrologic groups: (1) the Knox aquifer, formed by the Knox Group and the Maynardville Limestone (carbonate rocks), in which flow is dominated by solution conduits and which stores and transmits relatively large volumes of water; and (2) the ORR aquitards, made up of all other geologic units of the ORR (sandstones, siltstones, and shales), in which flow is controlled by fractures. These aquitards may store fairly large volumes of water, but they transmit only limited amounts.

The hydrologic groups are divided into the near-surface stormflow zone, the vadose zone, the groundwater zone, and the aquiclude (Solomon et al. 1992). Flow in the 3- to 7-foot-deep (1- to 2-meter) deep stormflow zone accounts for approximately 90 percent of the water moving laterally through the subsurface. The stormflow zone can transmit some water laterally to surface streams at approximately 39 feet (12 meters) per hour through large pores; however, less than 1 percent of the total void volume of the zone is large pores. Most water mass resides and migrates through smaller pores in the stormwater zone at rates 10 to 100 times slower. Advective-diffusive exchange between pores substantially reduces contaminant migration rates. A vadose zone between the stormflow and groundwater zones exists at the ORR except where the water table is at the land surface, such as along perennial stream channels. The vadose zone is thickest beneath ridges and thinnest or non-existent in valleys. Most groundwater movement through the vadose zone occurs vertically during precipitation events and occurs along discrete features such as fractures in the bedrock. Measurements of permeability, recharge, and conductivity vary considerably by locality in the vadose zone. Generally, conductivity is less than an inch (on the order of millimeters to centimeters) per day. The groundwater zone is the continuously saturated area in which the remaining 10 percent of lateral sub-surface water movement occurs. Very little water movement occurs in the deep aquiclude layer.

The Knox aquifer is the only true aquifer of the ORR and is the primary source of sustained natural flow in perennial streams such as Upper White Oak Creek, East Fork Poplar Creek, and Bear Creek (Solomon et al. 1992). In some places the Knox aquifer can supply large quantities of water to wells. Flow volumes are significantly larger than in the aquitards, and flow paths are deeper. The potential groundwater flow path length in the Knox aquifer is also substantially greater than in the aquitards--on the order of a few miles or kilometers. The one strongly suspected instance of groundwater flow across the ORR boundary occurs along the northeastern portion of Chestnut Ridge, where water in the Knox aquifer travels along a geological strike northeastward from the Y-12 Plant accross the ORR boundary. In March 1994, DOE announced that elevated levels of four industrial solvents (carbon tetrachloride, chloroform, tetrachloroethylene, and trichloroethylene) had been found in groundwater wells in the Knox aquifer, 2,500 feet east of the Y-12 Plant in the Union Vally Industrial Park (Bowdle 1994). The same solvents are found in groundwater monitoring wells at the Y-12 Plant. DOE is currently investigating the size and direction of the solvent plume. No proposed SNF management facilities would be sited in areas overlying the Knox aquifer.

Virtually all mobile water in the aquitards is discharged to local streams within the ORR. Flow in the ORR aquitards is shallow; about 98 percent occurs at depths of less than 100 feet (30 meters) (Solomon et al. 1992). Water in the aquitards travels through the uppermost part of the groundwater zone along flow paths of up to 1,000 feet (300 meters) in length before being discharged to local surface waters. Groundwater flow volume decreases and solute residence times increase sharply with depth. Mean solute transport rate in the stormflow zone is on the order of meters per hour, but in the intermediate and deep intervals of the groundwater zone, representative transport rates are as low as a few centimeters per year. Additionally, the mobility of most contaminants on the ORR is greatly reduced by sorption onto subsurface solids. Residence times of solutes near the water table in the aquitards range from a few days to a few years. In the intermediate and deep intervals, estimates of residence times range from hundreds to tens of thousands of years. Most groundwater flow in the aquitards occurs through a few widely spaced (23-164 feet [7-50 meters]) permeable regions.

Water in the aquitards is at best a marginal resource (Solomon et al. 1992). A typical well yields under 0.25 gallon per minute (0.02 liter per second). In many places, wells are incapable of producing enough water to support a typical household.

Background groundwater quality at the ORR is generally good in the surficial aquifer zones and poor (because of high total dissolved solids) in the bedrock aquifer at depths greater than 1,000 feet (300 meters) (DOE 1993a). Water in the surficial aquifer is typically a nearly neutral to moderately alkaline calcium bicarbonate type. Transport processes in the subsurface (including diffusion from fractures to the rock matrix, sorption, and exchange) have resulted in an accumulation of contaminants downgradient of the sources (Solomon et al. 1992).

Contaminated sites in need of environmental restoration include past-practice waste disposal sites, waste storage tanks, spill sites, and contaminated inactive facilities (DOE 1993a). Principal groundwater contaminants that exceed applicable standards at the Y-12 Plant include volatile organics, nitrates, heavy metals, and radioactivity (MMES 1993a). Exact rates and extent of the contamination have not been quantified. However, data indicate that most contamination remains relatively close to the source. As an example of the maximum extent of groundwater contamination, nitrate has been detected in wells 3,000 feet (920 meters) southwest of the source. Nitrate is relatively mobile in groundwater and may therefore define the maximum horizontal migration of contamination. At the ORNL, 20 waste area groupings have been identified and are being monitored for groundwater contamination. Monitoring data from each waste area group will direct further groundwater studies. At the K-25 Site, organics are the most commonly detected groundwater contaminants. Elevated levels of gross alpha and gross beta have also been detected in a number of wells. Uranium and technetium-99, respectively, appear to be primarily responsible for the elevated gross alpha and gross beta levels. The metals chromium, lead, arsenic, and barium have been detected in a number of wells at concentrations exceeding drinking water standards. Elevated levels of fluoride and polychlorinated biphenyls have also been detected in some wells.

In 1989, the Oak Ridge National Laboratory implemented an off-site residential drinking water quality monitoring program (MMES 1993a). The program objective is to document groundwater quality near the ORR and to monitor the potential impact of ORR operations on groundwater quality.

Parameters monitored under the program include volatile organics, metals, anions, and various radioactive parameters. Radionuclides and organics have been detected in some of the off-site monitoring wells, however, concentrations have been below drinking water standards. Fluoride has been detected at concentrations exceeding drinking water standards in one of the off-site wells. The high fluoride concentrations and accompanying high pH are most likely attributed to natural chemical reactions in the substrate. No sources or flow paths have been identified for the other constituents detected.

Although surface water sources provide the main portion of potable water supplies in the area, groundwater does provide for some domestic, municipal, farm, irrigation, and industrial use (MMES 1993a). Single-family wells are common in areas not served by public water supplies (MMES 1992a). However, because of the abundance of surface water and its proximity to the points of use, almost no groundwater is used at the ORR (DOE 1993a). Only one supply well exists on the reservation; it provides a supplemental supply to an aquatics laboratory.

All aquifers at the ORR are classified as Class II (DOE 1993a). Class II groundwaters are current and potential sources of drinking water and those waters having other beneficial uses. There are no sole-source aquifers beneath the ORR (DOE 1993a). Water rights are not an issue in the region.

4.9 Ecological Resources

Land for the ORR was primarily in agricultural use at the time of acquisition by the DOE's predecessor agencies. Clearings for orchards and pastures were on some of the upper slopes, rocky areas, and ridgetops; tillage crops were raised on the lower slopes and bottomland. Severe soil erosion also occurred in some areas. Except on very steep slopes, most of the forests had been cut for timber, though not necessarily cleared for agricultural uses. Natural plant communities have since reestablished themselves on most of the ORR, although many areas are maintained as pine plantations or nonforested areas (ORNL 1988). Plant communities at the ORR are characteristic of the intermountain regions of central and southern Appalachia. Approximately 10 percent of the ORR has been developed since it was withdrawn from public access; the remainder of the site has reverted to or been planted with natural vegetation (MMES 1989).

Biotic media, such as fish and deer, that may be affected by the releases or that might provide pathways of exposure to people are included in the environmental surveillance programs at the ORR. Bluegill (Lepomis macrochirus) and whitetail deer (Odocoileus virginianus) are routinely analyzed for radionuclide contamination. In 1992, the maximum doses to man projected from actual measurements were within the applicable regulatory requirements (see Section 4.12.4 and 4.12.5) (MMES 1993a).

The following describes biotic resources at the ORR, including terrestrial resources, wetlands, aquatic resources, and threatened and endangered species. Within each biotic resource area, the discussion focuses first on the ORR as a whole and then on the proposed site.

4.9.1 Terrestrial Resources

The vegetation of the ORR has been categorized into seven plant communities (Figure 4.9-1) (Parr and Pounds 1987). The pine and pine-hardwood forest is one of the most extensive plant communities on the ORR. Important species of this community type include loblolly pine (Pinus taeda), shortleaf pine (Pinus echinata), and Virginia pine (Pinus virginiana) (Parr and Pounds 1987). Another abundant plant community is the oak-hickory forest, which is commonly found on ridges throughout the ORR. Northern hardwood forest and hemlock-white pine-hardwood forest are the rarest plant community types on the ORR. Currently, timber on the ORR is managed by thinning young stands and harvesting mature stands. Timber is also sold when an area is to be cleared for development (Bradburn 1994). A total of 899 species, subspecies, and varieties of plants have been identified on the ORR (Mann et al. 1985; Cunningham and Pounds 1991).

Thirty areas on the ORR that are representative of the vegetational communities of the southern Appalachian region or that possess unique biotic features have been designated by DOE as National Environmental Research Park Reference Areas (Pounds et al. 1993). Several of these areas are wetlands.

Figure 4.9-1. Oak Ridge Reservation plant communities. The ORR provides habitat for a large number of animal species. Twenty-six species of amphibians, 33 species of reptiles, 169 species of birds, and 39 species of mammals have been recorded (Parr and Evans 1992). Habitats dominated by hardwood trees support the greatest number of wildlife species, followed in order by wetlands, old fields, and pine plantations (ORNL 1988).

Game animals present on the ORR include the whitetail deer, which has been hunted on the reservation since 1985 (MMES 1992b). Animals commonly found on the ORR include the American toad (Bufo americanus), eastern garter snake (Thamnophis sirtalis), Carolina chickadee (Parus carolinensis), northern cardinal (Cardinalis cardinalis), white-footed mouse (Peromyscus leucopus), and raccoon (Procyon lotor). Raptors, such as the red-shouldered hawk (Buteo lineatus) and great horned owl (Bubo virginianus), and carnivores, such as the gray fox (Urocyon cinereoargenteus) and mink (Mustela vison), are ecologically important groups on the ORR (Loar et al. 1981).

The surrounding countryside has much greater proportions of cultivated fields, pastures, and residential areas than the ORR, and much more fragmented forest cover. Because of the greater continuity of forests and a lack of human disturbance over much of the ORR, wildlife species that are affected by forest fragmentation offsite may find an abundance of suitable habitat on the ORR. Thus, the ORR may serve as a refuge for wildlife and as a source of wildlife migration (ORNL 1988).

Vegetative communities of the West Bear Creek site are typical of the ORR as a whole, composed of second-growth oak-hickory forest and mixed pine-hardwood forest. There are some loblolly pine plantations adjacent to the northern edge of the powerline right-of-way and between the right-of-way and Bear Creek Road (Rosensteel 1994). There are no National Environmental Research Park Reference Areas on the SNF site. Fauna of the site would also be similar to those expected throughout the ORR.

4.9.2 Wetlands

Wetlands on ORR have recently been evaluated based on National Wetland Inventory maps and field surveys of vegetation (Cunningham and Pounds 1991). Soils and hydrology were not specifically considered in this survey. Wetlands on the ORR include emergent, scrub/shrub, and forested wetland located in embayments of the Melton Hill and Watts Bar Reservoirs that border ORR; along all the major streams, including East Fork Poplar Creek, Poplar Creek, Bear Creek, and their tributaries; in old farm ponds; and around groundwater seeps.

Several well-developed emergent communities greater than 1 acre (0.004 square-kilometers) occur in shallow embayments of the reservoirs. The emergent communities typically grade into marshy areas adjoining forested wetlands. Most forested wetland sites are typically less than 1 acre, although forested wetlands greater than 1 acre are found along the East Fork Poplar Creek and the Clinch River near Gallahar Bridge. Ponds on the ORR vary in size and support diverse flora and fauna. Other wetland areas exist along utility rights-of-way, especially in Bear Creek and Melton Valleys (Cunningham and Pounds 1991).

Originating on the lower slopes of Pine Ridge are several headwater tributary systems of Grassy Creek that flow from north to south across the West Bear Creek site. The stream valleys contain forested wetlands. A powerline right-of-way crosses the stream bottoms, where the vegetation is dominated by wetland scrubs and herbaceous species, of which a portion adjacent to the west boundary has been designated a National Environmental Research Park Natural Area for the protection of state-listed rare plant species.

4.9.3 Aquatic Ecology

Aquatic habitats on or adjacent to the ORR range from small, free-flowing streams in undisturbed watersheds to larger streams with altered flow patterns because of dam construction. These aquatic habitats include tailwaters, impoundments, reservoir embayments, and large and small perennial streams.

Sixty-four fish species have been collected on or adjacent to the ORR. The minnow family has the largest number of species and is numerically dominant in most streams (ORNL 1988). Representative fish species of the Clinch River in the vicinity of the ORR are shad (Dorosoma sp.), herring (Alosa sp.), common carp (Cyprinus carpio), catfish (Ictalurus sp.), bluegill, crappie (Pomoxis sp.), and drum (Aplodinotus sp.) (Loar et al. 1981). Important fish species taken commercially in the ORR area are common carp and catfish. Recreational species include crappie, bass (Micropterus sp.), sauger (Stizostedion canadense), sunfish (Lepomis sp.), and catfish (Rector 1994).

Results from the ORNL monitoring program indicate varying degrees of impact on the benthic communities of the small perennial streams resulting from past waste disposal practices. Portions of these streams are dominated by pollutant-tolerant insect species (Loar 1992).

Portions of certain streams on the ORR have been designated by DOE as National Environmental Research Park Aquatic Natural or Reference Areas. These areas generally represent nonimpacted streams or reaches of streams and are used primarily for reference areas as part of the biological monitoring and abatement programs or environmental remediation efforts at ORR facilities. There are presently eight Aquatic Natural Areas and nine Aquatic Reference Areas (Pounds et al. 1993). Many of the Aquatic Natural Area streams contain the Tennessee dace, a species listed as in need of management by the State of Tennessee.

The aquatic resources occurring in the area of the West Bear Creek site are limited to several headwater tributary systems of Grassy Creek originating on the lower slopes of Pine Ridge and flowing from north to south across or adjacent to the site. Fifteen fish species have been recorded in Grassy Creek.

A National Environmental Research Park Aquatic Reference Area is located along Grassy Creek and its tributaries, one of which runs through the eastern portion of the proposed site. Grassy Creek has a diverse assemblage of invertebrates and fish species for a stream its size. The ORR uses Grassy Creek as a reference area for studies of other streams affected by site development (Pounds et al. 1993).

4.9.4 Threatened and Endangered Species

Federally and state-listed threatened, endangered, or other special-status species designated by the Endangered Species Act and/or the state's Nongame and Endangered Species and the Rare Plant Protection and Conservation Laws that have a reasonable potential for occurrence on the ORR are listed in Table 4.9-1. The table indicates that 25 of these species have recent records of occurrence on the ORR. The potential occurrence of the other 22 species listed is due to historical record, proximity to geographic ranges, and migratory nature of species. No critical habitat for threatened and endangered species, as defined in the Endangered Species Act (U.S. DOI 1992), exists on the ORR.

Although not all of the ORR has been surveyed for rare species, 33 different areas harboring rare plant species (federally or state-listed) have been designated as National Environmental Research Park Natural Areas by DOE (Pounds et al. 1993). The plant species listed in Table 4.9-1 are scattered among these Natural Areas but are not excluded from other areas on ORR. These Natural Areas are designated to provide protection for rare plant and animal species. The designated areas include river and creek bluffs, calcareous barrens, mesic forests, flood plains, and wetland cover classes.

No animal species listed by the Federal Government as threatened or endangered are known to reside on the ORR (Kroodsma 1987). The bald eagle (Federal, endangered) is a winter visitor to Watts Bar Lake and Melton Hill Lake. None of the species listed in Table 4.9-1 have been recorded on the proposed West Bear Creek Valley site. The purple fringeless orchid occurs in a Natural Area adjacent to the western border of the site (Pounds et al. 1993). Pink lady's-slippers are expected to occur throughout the Pine Ridge area (MMES 1992a). Preferred habitat within the site indicates a greater potential for occurrence of the barn owl, black vulture, Cooper's hawk, red-shouldered hawk, and sharp-shinned hawk. Surveys of the proposed site will be required to verify the presence of these and other plant and animal species.

Table 4.9-1. Federally and state-listed threatened, endangered, and other special-status species that potentially occur on or in the vicinity of the Oak Ridge Reservation.

Common name	Scientific name	Status[b]	
		Federal	State
Plants			
Appalachian bugbane[c]	Cimicifuga rubifolia	C2	T
Butternut	Juglans cinerea	C2	T
Canada (wild yellow) lily[c]	Lilium canadense	NL	T
Carey's saxifrage[c]	Saxifraga careyana	NL	S
Fen orchid[c]	Liparis loeselii	NL	E
Ginseng[c]	Panax quinquefolius	NL	T
Golden seal[c]	Hydrastis canadensis	NL	T
Gravid sedge[c]	Carex gravida	NL	S
Lesser lady's tresses[c]	Spiranthes ovalis	NL	S
Michigan lily	Lilium michiganense	NL	T
Mountain witch alder[c]	Fothergilla major	NL	T
Northern bush honeysuckle[c]	Diervilla lonicera	NL	T
Nuttall waterweed[c]	Elodea nuttallii	NL	S
Pink lady's-slipper[c]	Cypripedium acaule	NL	E
Purple fringeless orchid[c]	Platanthera peramoena	NL	T
Spreading false foxglove[c]	Aureolaria patula	C1	T
Tall larkspur[c]	Delphinium exaltatum	C2	E
Tubercled rein-orchid[c]	Platanthera flava var. herbiola	NL	T
Virginia spiraea	Spiraea virginiana	T	E
Fish			
Flame chub	Hemitremia flammea	NL	D
Tennessee dace[c]	Phoxinus tennesseensis	NL	D
Amphibians			
Green salamander	Aneides aeneus	NL	D
Hellbender[c]	Cryptobranchus alleganiensis	C2	D
Tennessee cave salamander[d]	Gyrinophilus palleucus	C2	T
Reptiles			
Cumberland turtle	Chrysemys scripta troosti	NL	D
Eastern slender glass lizard	Ophisaurus attenuatus longicaudus	NL	D
Northern pine snake	Pituophis melanoleucus	C2	T
Six-lined racerunner[d]	Cnemidophorus sexlineatus	NL	D
Birds			
Bachman's sparrow	Aimophila aestivalis	C2	E
Bald eagle[e]	Haliaeetus leucocephalus	E	E
Birds (continued)			
Barn owl[c]	Tyto alba	NL	D
Bewick's wren	Thyromanes bewickii altus	C2	T
Black-crowned night heron[c]	Nycticorax nycticorax	NL	D
Black vulture[c]	Coragyps atratus	NL	D
Cooper's hawk[c]	Accipiter cooperii	NL	T
Grasshopper sparrow	Ammodramus savannarum	NL	T
Northern harrier	Circus cyaneus	NL	T
Osprey[c]	Pandion haliaetus	NL	E
Peregrine falcon	Falco peregrinus	E	E
Red-shouldered hawk[c]	Buteo lineatus	NL	D
Redheaded woodpecker	Malanerpes erythrocephalus	NL	D
Sharp-shinned hawk[c]	Accipiter striatus	NL	T
Mammals			
Eastern woodrat	Neotoma floridana magister	C2	D
Gray bat	Myotis grisescens	E	E
Indiana bat	Myotis sodalis	E	E
Smoky shrew	Sorex fumeus	NL	D
Southeastern shrew	Sorex longirostris	NL	D

a. Sources: Barclay (1990, 1992); Bay (1991); Cunningham et al. (1993); Hardy (1991), Hardy et al. (1992); Kitchings and Story (1984); Kroodsma (1987); ORNL (1981); ORNL (1988); TDEC (1992a, 1992b, 1992c, 1992d); TWRC (1991a, 1991b); U.S. DOI (1990, 1991, 1992).

b. Status codes:
C1 = Federal Candidate - Category 1 (probably appropriate to list)
C2 = Federal Candidate - Category 2 (possibly appropriate to list, more study required)
D = species deemed in need of management
E = endangered
NL = not listed
S = species of special concern
T = threatened, more study required

c. Recent record of species occurrence on the ORR.

d. Species collected on the ORR in 1964 (ORNL 1988).

e. Observed near ORR on Melton Hill and Watts Bar Lakes.

4.10 Noise

The major noise sources within the ORR occur primarily in developed operational areas and include various facilities, equipment, and machines (e.g., cooling towers, transformers, engines, pumps, boilers, steam vents, paging systems, construction and materials-handling equipment, and vehicles). Major noise sources outside the operational areas consist primarily of vehicles and railroad operations. At the site boundary, away from most of these activities, noise from these sources would be barely distinguishable from background noise levels. Some disturbance of wildlife activities might occur on the ORR as a result of operational activities and construction activities.

Sound-level measurements have been made around the ORR in the process of testing sirens and preparing support documentation for the Atomic Vapor Laser Isotope Separation site (Cleaves 1991). The acoustic environment along the ORR site boundary in rural areas and at nearby residences away from traffic noise is typical of a rural location, with the average day-night sound level in the range of 35 to 50 decibels, A-weighted. Areas near the site within Oak Ridge are typical of a suburban area with the average day-night sound level in the range of 53 to 62 decibels, A-weighted (EPA 1974). The primary source of ORR noise at the site boundary and at residences near the site boundary is traffic, including trucks, private vehicles, and freight trains. During peak hours, plant vehicular traffic is a major contributor to traffic noise levels in the area. In addition, some noise due to air cargo and business travel via commercial air transport through the airport at Knoxville can be attributed to ORR operations. Section 4.11 (Traffic and Transportation) discusses vehicular, air, and rail transportation.

The State of Tennessee has not established specific numerical environmental noise standards applicable to the ORR. The City of Oak Ridge has specified allowable noise levels at property lines as shown in Table 4.10-1.

During a normal week, about 17,000 employees travel to the ORR each day in private vehicles from surrounding communities. In addition, both government-owned and private trucks pick up and deliver materials at the site. Based on the number of employees, it was estimated that about 33,000 vehicle trips are generated to and from the site each day; mostly on Tennessee State Routes 58, 62, 95,

Table 4.10-1. City of Oak Ridge maximum allowable noise limits applicable to the ORR.

Adjacent uses	Where measured	Maximum sound level (dBA)b
All residential districts	Common lot line	50
Neighborhood business district	Common lot line	55
General business district	Common lot line	60
Industrial district	Common lot line	65
Major streets	Street lot line	75
Secondary residential streets	Street lot line	60

a. Source: City of Oak Ridge (1984).

b. Decibels, A-weighted.

and 162, which pass through the ORR and are open to the general public. Both government-owned and private trucks pick up and deliver materials at the site. The contribution of ORR operations to traffic volumes along these routes, especially during peak traffic periods, affects noise levels in the immediate vicinity of the ORR and through the City of Oak Ridge.

Use of the railroad branches from the CSX and the Norfolk Southern Corporation lines to deliver and pick up shipments at the ORR may cause some noise impacts along these routes. Twice a week service is scheduled to Y-12 from the CSX line. However, only 60 cars were delivered in 1993. Service to K-25 is provided as needed. Only three or four trains serviced K-25 in 1993. However, two or three trains per week may be required beginning in 1994 (Pearman 1994). Noise sources from rail transport include diesel engines, wheel-track contact, and whistle warnings at rail crossings.

4.11 Traffic and Transportation

Traffic congestion is measured by level of service. Level of service A represents free flow of traffic. Level of service B is in the range of stable flow, but the presence of other users in the traffic stream begins to be noticeable. Level of service C is in the range of stable flow, but marks the beginning of the range of flow in which the operation of individual users becomes significantly affected by interactions with others in the traffic stream. Level of service D represents high-density, but stable, flow. Level of service E represents operating conditions at or near the capacity level. Level of service F is used to define forced or breakdown flow. The calculated level of service are for discrete locations along a segment. Level of service will most likely be worse in urban areas and better in rural areas along the segment.

The Region of Influence for the ORR includes site roads and regional roads in Anderson, Blount, Knox, Loudon, and Roane counties. Regional and local transportation routes are presented in Figure 4.11-1 and Figure 2.1-2.

Primary roads on the ORR include Tennessee State Routes 95, 62, 162, and 170 (Bethel Valley Road), and Bear Creek Road. Except for Bear Creek Road, all are public roads. The remaining roads on the ORR are private. Interstate 75 and Tennessee State Routes 162, 62, and 61 form a loop around ORR.

Figure 4.11-1. Oak Ridge Reservation regional transportation map. Bear Creek Road, Bethel Valley Road, Tennessee State Routes 62 and 95 experience high average traffic and peak hour volume. Other areas on the site that have traffic problems include Scarboro Road, security entrances, and intersections.

Current baseline traffic (i.e., 1995) along segments providing access to the ORR is projected to contribute to differing service level conditions (TDOT 1993). Tennessee State Route 61 would operate at level of service D between Interstate 75 at Norris and U.S. Route 25W at Clinton, and at level of service C between U.S. Route 25W at Clinton to Tennessee State Route 62 east of Oliver Springs. Tennessee State Routes 58 and 170 (providing access from the east), as well as Bear Creek Valley Road, would operate between level of service D and B. Tennessee State Routes 62 and 95 would operate at widely varying levels of service in the vicinity of ORR. Tennessee State Route 62 would operate at a level of service E between Tennessee State Route 95 at Oak Ridge and Tennessee State Route 170. Tennessee State Route 95 would operate at a level of service E between Tennessee State Route 61 and Tennessee State Route 62 at Oak Ridge.

Road reconstruction, widening, modification of interchanges, and new interchange construction projects are planned for segments of Bear Creek Valley Road, Scarboro Road, and Tennessee State Routes 58, 62, and 95 (Johnson, C. 1994; MMES 1991b).

Current baseline traffic along segments providing regional access to the ORR is projected to contribute to differing service level conditions. Interstate 40 passes within 5 miles (8 kilometers) to the south of the ORR. It has a level of service of A to B between U.S. Route 27 at Harriman to Interstate 75, which passes northeast about 11 miles (18 kilometers) and south about 3 miles (5 kilometers) of the ORR. U.S. Route 25W passes the ORR about 10 miles (16 kilometers) to the east and northeast. It has a level of service of D to E between Interstate 75 at Lake City to Tennessee State Route 131.

In 2001, when site-related impacts are at their highest along segments providing access to the ORR, background traffic is projected to contribute to differing service level conditions for local roads. Tennessee State Route 61 would operate at level of service D between Interstate 75 at Norris and U.S. Route 25W at Clinton and level of service C between U.S. Route 25W at Clinton to Tennessee State Route 62 east of Oliver Springs. Tennessee State Routes 58 and 170 as well as Bear Creek Valley Road would operate between level of service D and B. Tennessee State Routes 62 and 95 would operate at widely varying levels of service in the vicinity of the ORR, with a level of service F between Tennessee State Route 95 at Oak Ridge and Tennessee State Route 162. U.S. Routes 11/70 would operate at level of service F between Tennessee State Route 131 and U.S. Routes 11E/11W Split. All other local roads operate at level of service E or better (University of Tennessee 1993). Interstate 40 has a level of service B to D between U.S. Route 27 at Harriman to Tennessee State Route 162.

The level of service was calculated using average daily traffic counts (TDOT 1990) and standard parameters (ITE 1991; TRB 1985; Rand McNally 1993).

No public transportation service exists in the City of Oak Ridge. Other modes of transportation within the Region of Influence include railways and waterways. Railroad service in the Region of Influence is provided by CSX Transportation and the Norfolk Southern Corporation. Two main lines serve the ORR. A CSX Transportation spur line serves the ORR site as well as the City of Oak Ridge. Waterborne transport in the Region of Influence is via the Clinch River, which provides an alternative mode of transportation to the Oak Ridge area. The Clinch River waterway has rarely been used for DOE business, and no designated port facilities exist for such purposes (Corps 1991).

McGhee Tyson Airport in Knoxville, 40 miles (64 kilometers) from the ORR, receives jet air passenger and cargo services from both national and international carriers. The closest air transportation facility to ORR is Atomic Airport in Oliver Springs. Numerous other private airports are located throughout the Region of Influence (DOT 1991).

4.12 Occupational and Public Health and Safety

The Department of Energy's Oak Ridge Reservation released chemicals and small quantities of radionuclides to the environment from operations at all facilities during 1992. These releases are quantified and characterized in detail in the Oak Ridge Environmental Report for 1992. This release information, along with estimates of the potential consequences resulting from these releases, is summarized in greater detail within sections 4.7, 5.7, 4.8, and 5.8 for the purpose of characterizing the existing radiation and chemical environment. The ORR baseline data presented within this section are expected to remain essentially constant between 1992 and 1995 (the year in which SNF operations are expected to commence).

Health effects from radiation are presented here as the risk of fatal cancer. This risk is in the ratio of the health risk estimator (risk of fatal cancer per rem of exposure). The value of this estimator for exposures to the public is 5 x 10-4 for fatal cancers. The corresponding estimator for exposures to workers is 4 x 10-4.

4.12.1 Atmospheric Emissions and Doses

Table 4.7-1 in Section 4.7 illustrates the breakdown of radioactive emissions to the atmosphere from each of the three ORR operations areas (ORNL, K-25, and Y-12), during 1992. The calculated total dose of 3.3 millirem/year due to 1992 operations, to the maximally exposed individual at the site boundary, is well within the 10 millirem/year limit given in 40 CFR Part 61 (the U.S. Environmental Protection Agency's National Emission Standards for Hazardous Air Pollutants) (MMES 1993a).

The concentrations at the ORR boundary of all radionuclides released to the atmosphere from the three operations areas in 1992 were less than 1 percent of the DOE Derived Concentration Guide, which is based upon an exposure of 100 millirem; this equates to a dose of less than 1 millirem (MMES 1993a).

The associated isotopic gaseous release cancer risks are presented within Section 4.12.4.

Table 4.7-2 in Section 4.7 presents the chemical releases for 1992 in a fashion analogous to Table 4.7-1. All of these releases are within permitted levels. The associated chemical release cancer risks are presented within Section 4.12.6.

4.12.2 Groundwater/Surface Water Contamination and Doses

Referring to the various water contamination data presented in Section 4.8, it was found that a plausible 0.62 mrem/year of site operation could be incurred by a potential maximally exposed individual at the site boundary due to water ingestion, fish ingestion, and other associated factors (see **Table 4.12-1) (MMES 1993a).**

Additionally, a dose of 17 mrem/year of site operation could be incurred by this potential maximally exposed individual, due to external exposure from contaminated liquid effluents (see Table 4.12-1). Fifteen mrem/year of this dose would result from a hypothetical individual fishing for 250 hours/year along Poplar Creek near the K-25 storage areas (MMES 1993a).

Table 4.12-1. Summary of estimated radiation dose to public from 1992 operations at ORR.

Pathway	Location of maximally exposed individual	Committed effective dose equivalent to maximally exposed individual (mrem)	Collective committed effective dose equivalent (person-rem)a
Gaseous effluents	Nearest resident to		
Inhalation plus direct radiation from air, ground, and food chains	Y-12 Plant	2.7	29
	ORNL	0.06	2
	K-25 Site	0.53	21
	ORR	3.3	52
Liquid effluents			
Drinking water	Gallaher	0.2	0.85
Eating fish	Poplar Creek	0.4	1.0b
Other activities	Poplar Creek	0.02	
Direct radiationb	Clinch River shoreline	2	
	Poplar Creek (K-25 Site)	15	

a. Within 80 kilometers (50 miles) of the ORR.

b. Includes doses from all liquid pathways (MMES 1993a).

The associated cancer risks related to these doses are presented in Section 4.12.4.

4.12.3 External Gamma Radiation

External gamma radiation measurements were made with thermoluminescent dosimeters at locations coinciding with the ambient air locations. The average external gamma radiation level at the ORR perimeter for 1992 was 7.6 microroentgens per hour. All of the measurements were well within the range of typical values for cities in the United States (MMES 1993a).

4.12.4 Radiation Dose and Health Effects Summary (Public and ORR Workers)

A summary of the effective dose equivalents to the hypothetical maximally exposed individual from the important pathways of exposure during 1992 is presented in Table 4.12-1. If the resident who receives the highest effective dose equivalent (3.3 millirem) from gaseous effluents also drank water from the Gallaher area (0.2 millirem), and went fishing at Poplar Creek (for 250 hours/year) near the K-25 site (15 millirem), that individual would receive a total effective dose equivalent of approximately 18.5 millirem, which is roughly 6.3 percent of the annual dose (295 millirem) from natural background radiation (see Figure 4.7-2). All of these doses are within the applicable regulatory requirements, (i.e., 4 millirem/year from the drinking water pathway, 10 millirem/year from the airborne release pathways, and 100 millirem/year total for all pathways) (MMES 1993a).

The risk of fatal cancer to the maximally exposed individual at the site boundary (due to atmospheric emissions only) is 1.7 x 10-6 per year of operation, and the corresponding (ingestion) risk to this maximally exposed individual from drinking water is 1.0 x 10-7 per year of operation. The risk of fatal cancer from direct radiation due to an individual's spending 250 hours/year fishing at Poplar Creek (K-25 Site) is 7.5 x 10-6 per year of exposure. A more realistic maximally exposed individual scenario from direct radiation, an individual spending 250 hours/year along the Clinch River shoreline near a field on which cesium-137 experiments were performed, yields an associated risk of 1 x 10-6. The resulting risk to the maximally exposed individual is 9.2 x 10-6 per year of operation; over the 40-year SNF management facility lifetime this risk would be 3.7 x 10-4. Table 4.12-1 also includes the collective doses to the general population within 50 miles (80 kilometers) of the ORR. It was found that approximately 54 person-rem (which translates to an expected 0.027 fatal cancer) were received (from liquid and gaseous effluents) by this population from 1992 ORR operations. Thus, over a 40-year period, there would be approximately 1.1 fatal cancers expected.

Doses to onsite workers at the ORR have been reported by DOE for 1991 operations. Of the approximately 17,000 workers monitored, the maximally exposed individual was reported to receive 1 to 2 rem (assumed as 2 rem), which is well below the DOE guidelines of 5 rem (DOE 1992a). The average dose to workers at the site was 2.8 mrem/yr. The risk of fatal cancer to the average worker is 1.1 x 10-6 per year of operation; the risk to a worker who spent 40 years at ORR is approximately 4.5 x 10-5. Additionally, the total collective (population) dose received by these workers was 48 person-rem, which corresponds to 0.019 fatal cancers per year of exposure. Over a 40-year period, there would be an expected 0.76 fatal cancer to this worker population.

4.12.5 Health Effects Studies

Two epidemiologic studies were conducted to determine whether the ORNL facility contributed to any excess cancers in the communities surrounding the facility. One study found no excess cancer mortality in the population living in counties surrounding ORNL when compared to the control populations located in other nearby counties and elsewhere in the United States (Jablon et al. 1991). The other found slight excess cancer incidences of several types in the counties near ORNL, but none of the excess risks were statistically significant (Sharpe 1992).

An Oak Ridge health assessment study is ongoing. This study will include a reconstruction of doses received by the public from historical releases of radioactivity from the reservation. To date, a Phase I report has been issued (Tennessee Department of Health and the Oak Ridge Health Agreement Steering Panel 1993).

Studies of workers at Oak Ridge National Laboratory (Jablon et al 1991; Wing et al. 1993) showed an excess of leukemia deaths among maintenance workers and engineers who had worked for more than 10 years, suggesting a possible excess attributed to exposures other than radiation. An increase of 2.68 percent in deaths from all causes and 4.94 percent for all cancers with every rem of cumulative dose exposure with a 20-year exposure lag was also reported. Excess cancer deaths were associated with working in radioisotope production and chemical operations but not with work in physics, engineering, or unknown job categories. Cancer mortality was also associated with exposure to beryllium, lead, and mercury.

In March 1990, the Secretary of Energy announced that DOE would turn over responsibility for analytical epidemiologic research on long-term health effects on workers at DOE facilities and surrounding communities to the Department of Health and Human Services, and directed that worker health and exposure data be released. A Memorandum of Agreement with the Department of Health and Human Services was signed in January 1991. The Department of Health and Human Services is now conducting the ongoing health effects research program. To develop a database on workers, DOE has initiated an Epidemiologic Surveillance Program and Health-Related Records Inventory.

4.12.6 Chemical Dose and Health Effects Summary

Table 4.7-2 in Section 4.7 presents the ORR chemical releases for 1992. Exposure to chemicals released from the ORR was compared with acceptable levels of exposure (no adverse effect from noncarcinogens) for the ingestion exposure pathway via drinking water and consumption of fish. Aluminum, nitrate, and polychlorinated biphenyls were measured above acceptable levels in upper Bear Creek; the ratios of their doses to acceptable doses were 3.4, 2.2, and 11.1, respectively. The only other chemical exposure attributable to ORR operations that was found to exceed acceptable levels was mercury. This noncarcinogen was found in fish caught from the Clinch River. The ratio of the mercury dose to acceptable dose levels was found to be 1.1 (MMES 1993a).

Because of concerns for possible contamination of the population by mercury, the Tennessee Department of Health and Environment conducted a pilot study in 1984. The study showed no difference in urine or hair mercury levels between individuals with potentially high mercury exposures (residence or activity in contaminated areas based on soil measurements or consumption of fish caught in the contaminated areas) and those with little potential exposure. Mercury levels in some soils measured as high as 2,000 parts per million. Analysis of a few soil samples showed that most of the mercury in the soil was inorganic, however, thereby lowering the probability of bioaccumulation and health effects.

Planned occupational studies at the ORR include a 24-month clinical follow-up of 111 heavily exposed mercury workers (Wing et al. 1991).

4.13 Utilities and Energy

4.13.1 Water Consumption

Both the Clinch River and the Melton Hill Reservoir supply water to the ORR. Because they are a part of the TVA flood control system, they are capable of maintaining a constant volume of water well in excess of the demands of the ORR (MMES 1993a).

In 1995, water supply facilities at the ORR will have a capacity of approximately 1,761 liters per second (27,916 gallons per minute). In 1993, the average demand for water on the ORR water supply facilities was approximately 801 liters per second (12,708 gallons per minute) (Fritts 1994).

A pumping station near Y-12 on the Melton Hill Reservoir supplies untreated water to the DOE water treatment plant. After treatment, the water is stored in two reservoirs with a combined capacity of 26 million liters (7 million gallons). From the reservoirs, water is supplied by gravity flow to the Y-12 operations site, ORNL, the Scarboro Facility (which houses the Oak Ridge Institute of Science and Education's Energy/Environmental Systems Division), and the City of Oak Ridge (MMES 1994a).

A pumping station on the Clinch River provides water to the K-25 water system. After treatment, the water is stored in two water storage tanks on Pine Ridge. This system provides water to the K-25 Site, the Transportation Safeguards Facility, and the city's Clinch River Industrial Park (MMES 1994a).

The SNF facilities will be supplied with water from the K-25 water system. In 1995, the K-25 water system will have a capacity of approximately 184 liters per second (2,917 gallons per minute). In the years 1988 to 1994, K-25 water usage varied from a high of 97 liters per second (1,533 gallons per minute) in 1990 to a low of 78 liters per second (1,235 gallons per minute) in 1988. In 1994, the average demand was 84 liters per second (1,324 gallons per minute). Significant growth in water capacity or demand is not expected (Fritts 1994).

4.13.2 Electrical Consumption

The ORR electrical system is supplied power from four major power sources in the TVA system: Kingston Steam Plant, Bull Run Steam Plant, Wolf Creek Hydroelectric Plant, and Fort Loudon Hydroelectric Plant. The K-25 Power Operations Department manages and operates the electrical transmission and substation system of the ORR (MMES 1994a).

Three substations located at the K-25, Y-12, and ORNL sites comprise the ORR power system. The substations are tied together onsite by five DOE 161-kilovolt transmission lines. Power is supplied to ORR substations by six TVA electrical lines at 161 kilovolts, which is reduced to 13.8 kilovolts for distribution (MMES 1994a).

In 1995, the connected capacity of ORR facilities would be approximately 920 megavolt-amperes. From 1989 through 1993, the peak demand of electricity varied from a high of 116 megavolt-amperes in 1989 to a low of 98 megavolt-amperes in 1993 (Fritts 1994).

4.13.3 Fuel Consumption

The East Tennessee Natural Gas Company supplies natural gas to the ORR, transporting the gas from the supply areas through upstream pipelines and then through its own pipeline system for ultimate delivery to the ORR (MMES 1994a). By contract, ORR natural gas capacity is 7,600 decatherms. This amount can be increased if necessary. In 1994, the average daily usage of natural gas was 3,600 decatherms (Fritts 1994).

Coal is used to produce steam at ORNL and as a backup fuel at the Y-12 steam plant. Y-12 plans to use more coal in the future as a replacement for natural gas (Fritts 1994).

4.13.4 Wastewater Disposal

The ORR does not have a centralized sewage system for all facilities. The K-25 Site and ORNL have their own sewage systems, while Y-12 shares sewage lines with the City of Oak Ridge (MMES 1994a).

The sanitary sewage effluent from the Y-12 operations area flows to the Oak Ridge West End Treatment Plant. DOE maintains the sewage lines extending from Y-12 to the east end of the security road (Bear Creek Road). The City of Oak Ridge maintains the sewage lines from the end of the security road to the treatment plant on West Oak Ridge Turnpike (MMES 1994a).

The sewage treatment plant for ORNL discharges treated effluent into White Oak Creek in full compliance with all permit requirements (MMES 1994a). There are no anticipated capacity problems with the K-25 sanitary sewage system, which is permitted by the National Pollution Discharge Elimination system (MMES 1994a).

The SNF management facility could use the K-25 sanitary sewer treatment system, located directly north of the proposed SNF site. The K-25 system has a capacity of 26 liters per second (417 gallons per minute). From 1988 to 1994, wastewater production peaked at 24 liters per second (378 gallons per minute) during wet conditions in 1994 (Fritts 1994). As an alternative, a new onsite sanitary sewage system and wastewater treatment plant might be required for the proposed SNF management facility.

4.14 Materials and Waste Management

This section describes the hazardous materials management (chemical raw materials), the waste categories, and the ongoing waste management activities, including onsite treatment, onsite storage, onsite waste disposal, and preparation for appropriate offsite disposal, for the three primary complexes within the ORR: the Y-12 Plant, the K-25 Site, and the ORNL (see Figure 2.1-2). Ongoing nuclear-related activities at the ORR have resulted in the generation of low-level, mixed low-level, hazardous, transuranic, spent nuclear fuel (see Chapter 2 for discussion), and industrial solid waste categories, which are discussed in this section. Section 4.8 discusses nonhazardous liquid waste treatment. A description of the Y-12 Plant, the K-25 Site, and ORNL waste categories and the waste management process unique to each of these complexes follows.

Facilities at the Y-12 Plant are being used to manage low-level radioactive, hazardous (Resource Conservation and Recovery Act hazardous/mixed polychlorinated biphenyl and polychlorinated biphenyl/uranium), and nonhazardous solid wastes. Figure 4.14-1 shows the waste management process at the Y-12 Plant.

Figure 4.14-1. Flow diagram of Y-12 Plant storage and disposal units at ORR (Page 1 and 2). Figure 4.14-1. Flow diagram of Y-12 Plant storage and disposal units at ORR (page 2 of 2).

Facilities at the K-25 Site are being used to manage low-level radioactive, hazardous, and mixed wastes. Nonhazardous solid wastes are disposed at the Y-12 Plant Sanitary Landfill. Figure 4.14-2 shows the waste management process at the K-25 Site.

Facilities at the ORNL are being used to manage transuranic, low-level radioactive, hazardous, and mixed waste. Nonhazardous solid wastes are disposed at the Y-12 Plant Sanitary Landfill. Figure 4.14-3 shows the waste management process at the ORNL.

The overall ORR waste management activities, as well as details on the facilities used to manage wastes, are presented by waste category (transuranic, mixed low-level, low-level, hazardous, and industrial solid) in Sections 4.14.1 through 4.14.5 respectively. Note that the 1995 waste generation rates presented in tables associated with these sections are a representation of the annual generation rates for operations until the year 2035. Section 4.14.6 describes the management of the chemical raw materials used for ORR activities.

4.14.1 Transuranic Waste

The ORNL is the only complex at the ORR that generates and manages transuranic waste. Table 4.14-1 presents a summary of transuranic waste management activities projected for 1995, and details on the facilities used to manage transuranic wastes are presented in Table 4.14-2.

4.14.2 Mixed Low-Level Waste

All three complexes at the ORR generate and manage mixed low-level wastes. The Y-12 Plant, K-25 Site, and the ORNL manage non-Resource Conservation and Recovery Act wastes (polychlorinated biphenyls, beryllium, and asbestos) contaminated by low-level radioactive materials as dangerous substances and include them with the Resource Conservation and Recovery Act-regulated radionuclide-contaminated materials as mixed wastes. Table 4.14-3 presents a summary of mixed low-level waste management activities projected for 1995, and details on the facilities used to manage mixed low-level waste are presented in Table 4.14-4.

Figure 4.14-2. Flow diagram of K-25 waste storage units at ORR (Page 1 of 2). Figure 4.14-2. Flow diagram of K-25 waste storage units at ORR (page 2 of 2). Figure 4.14-3. Flow diagram of ORNL waste treatment units and storage and disposal units at ORR (Page 1 of 2).

Figure 4.14-3. Flow diagrams of ORNL waste treatment units and storage and disposal units at ORR (Page 2 of 2).

Table 4.14-1. Projected 1995 transuranic waste management activities at the ORR (ORNL complex).

Waste category	Generation rateb	Treatment	Treatment	Storage method	Storage capacity	Disposal method	Disposal capacity

		method	capacity				
Transuranic (Solid)							
Contact handled	10.7 m3	None	Not available	Staged	611.7 m3	WIPP[c], in future	To be determined
Remote handled	5.4 m3	None	Not available	Shielded storage	221.7 m3	WIPP[c], in future	To be determined

a. Sources: Snider (1993); Turner (1994).
b. 1991 data.
c. WIPP = Waste Isolation Pilot Plant

Table 4.14-2. Baseline transuranic waste management activities as of 1995 at the ORR (ORNL complex). ,b

Waste description	Facility number	Facility description	Facility storage capacity	Available disposal space
Transuranic	7802N	TRU[c] trenches	199 concrete casks	None
	7855	RH-TRU[d] waste storage facility	108 concrete casks	6 concrete casks
	7878	Interim storage facility	Not applicable (inspection facility)	Not applicable (inspection facility)
	7824	Waste examination and assay facility (dual use facility)	Not available	Not available
	7879	CH-TRU[e]/LLW[f] solids storage (dual storage facility)	372 m2	Facility full

a. Sources: PAI Corporation (1993a); Turner (1994).
b. 1993 data.
c. TRU = Transuranic waste.
d. RH-TRU = Remote-handled transuranic waste.
e. CH-TRU = Contact-handled transuranic waste.
f. LLW = Low-level (radioactive) waste.

Table 4.14-3. Projected 1995 mixed low-level waste management activities at the ORR.

Complex	Waste category	Generation rate	Treatment method	Treatment capacity	Storage method	Storage capacity	Disposal method	Disposal capacity
Y-12 Plant	Mixed solid[b]	242,869 kg[c] (573 m3/yr)	None	N/A	Staged for shipment	1,730 yd3 [d]	None, offsite to NTS pending	N/A
	Mixed liquid[b]	1,537,234 kg[e] (426,120 gal/yr)	Settlement and filtration	8,716 m3 yr (2.3 million gal/yr)	Tanks	573 m3 [f] (152,000 gal)	None, offsite to NTS pending	N/A
K-25 Site	Mixed liquid[g]	47,022.9 m3 [h]	Settlement and filtration/ incineration	58,400,000 gal	Onsite	97,167 m3 [i]	Not applicable	Not applicable
	Mixed solid[g]	535.2 m3[j]	Planned	Planned	Onsite	120,206 m3	None	Not applicable
ORNL	Mixed liquid[g]	Not reported	Ion exchange	259,199.4 m3	None	Not applicable	Not applicable	Not applicable
	Mixed solid[g]	48.9 m3 [k]	Planned	Planned	Staged for shipment	22,000 gal [l]	None, offsite to NTS pending	Not applicable

a. Sources: Snider (1993); Brown (1994c).

b. 1992 data.

c. Includes 37,434 kg of contaminated (radionuclides) asbestos beryllium oxide waste and 28,948 kg of polychlorinated biphenyl/uranium waste.

d. RCRA/PCB Warehouse (Building 9720-9), RCRA and PCB Container Storage Area (Building 9720-58), Container Storage Facility (Building

9720-12) and PCB Drum Storage Facility (Building 9407-7).

e. Includes 13,152 kg of polychorinated biphenyl/uranium waste.

f. OD-9 and OD-10.

g. 1991 data.

h. TSCA (Toxic Substances Control Act) incinerator waste water.

i. Includes permitted container (solid/sludges/liquid wastes) and tank (liquids) storage capacity.

j. May include some polychlorinated biphenyl-tainted waste.

k. Includes polychlorinated biphenyl and asbestos waste.

l. Mixed Waste Drum Storage Pads - Bldg 7507 W, Part A permit, 22,000 gal.

Table 4.14-4. Baseline mixed low-level waste management activities as of 1995 at the ORR.

Complex	Waste identification	Facility number	Facility description	Facility storage capacity	Available disposal space
Y-12 Plant	Mixedb	9201-4	Mixed waste storage area	350 55-gal drums	17 55-gal drums
		9404-7	PCB storage facility (dual storage/use)	See hazardous wastes	See hazardous waste
		9720-9	Mixed and PCBc storage area (dual storage/use)	See hazardous wastes	See hazardous waste
		9720-31	RCRAd staging and storage facility (dual storage/use)	See hazardous wastes	See hazardous waste
		9720-58	RCRAd and PCBc container storage area (dual storage/use)	See hazardous waste	See hazardous waste
		9811-1	Waste oil tank storage area, OD-7 (dual storage/use)	See hazardous waste	See hazardous waste
		9811-8	Waste oil solvent drum storage facility OD-8 (dual storage/use)	See hazardous waste	See hazardous waste
		9811-8	Organic liquid storage area, OD-9 (dual storage/use)	See hazardous waste	See hazardous waste
		None	Containerized waste storage area (dual storage/use)	See low-level waste	See low-level waste
K-25 Sitef	Mixede	K-1065A, B, C, D, E	Container storage	5097 m3	970 m3
		K-1419	Liquid waste storage facility	61 m3	Facility full
		K-31	Waste piles (dual storage/use facility)	6623 m3	Facility full
		K-33	Waste piles (dual storage/use facility)	8,506 m3	Facility full
		K-27	Withdrawal alleys and vaults	2,640,000 gal	Future facility
		K-27	Vault 31X	660,000 gal	Future facility
ORNL	Mixed	7075	Used oil storage tank	4,200 gal	Tank full (undergoing RCRAd closure)
		7507W	Mixed waste storage facility	82 m3	Facility full
		7654	Long term hazardous waste storage facility	62 m3	Facility full
		7823	Mixed waste storage facility	390 m3	117 m2
		7830A	Waste storage tank	5,000 gal	Tank full

a. Sources: PAI Corporation (1993b); PAI Corporation (1994); Turner (1994).

b. 1993 data.

c. PCB = Polychlorinated biphenyl.

d. RCRA = Resource Conservation and Recovery Act.

e. 1994 data.

f. For additional mixed waste facilities see hazardous waste facilities at the K-25 Site (Table 4.14-8).

4.14.3 Low-Level Waste

The Y-12 Plant, K-25 Site, and the ORNL generate and manage low-level wastes. Table 4.14-5 presents a summary of low-level waste management activities projected for 1995, and details on the facilities used to manage low-level waste are presented in Table 4.14-6.

4.14.4 Hazardous Waste

All three complexes at the ORR generate and manage hazardous wastes. The Y-12 Plant, K-25 Site, and the ORNL manage non-Resource Conservation and Recovery Act wastes (asbestos, oils, and polychlorinated biphenyls) as dangerous substances and include them with the Resource Conservation and Recovery Act-regulated wastes as hazardous wastes. Table 4.14-7 presents a summary of mixed hazardous waste management activities projected for 1995, and details on the facilities used to manage hazardous waste are presented in Table 4.14-8.

4.14.5 Industrial Solid Waste

The K-25 Site and the ORNL industrial solid wastes are disposed of at the Y-12 Plant Sanitary Landfill (PAI Corporation 1994; PAI Corporation 1993a). Table 4.14-9 presents a summary of industrial solid waste management activities projected for 1995 at the Y-12 Plant, and details on the facilities used to manage industrial solid waste are presented in Table 4.14-10.

4.14.6 Hazardous Materials

The ORR uses a variety of chemical raw materials for activities associated with metal finishing/plating, uranium recovery, laboratory services, cooling tower operation, and facility cleaning/maintenance operations. Examples of chemicals used at the ORR include acids (hydrochloric, nitric), organics (methanol, perchloroethylene), and inorganics (hydrogen fluoride, chlorine). Currently, 309 specific chemicals and 20 chemical categories are being reviewed for possible reporting under the Superfund Amendments and Reauthorization Act Section 313 requirements. For 1992, the ORR reported 7 extremely hazardous substances and 39 hazardous chemicals for the Y-12 Plant; 5 extremely hazardous substances and 16 hazardous chemicals for the K-25 Site; and 20 extremely hazardous substances and hazardous chemicals for ORNL (MMES 1993a).

In addition, diesel fuel and gasoline, used to fuel site service and construction vehicles, are stored in bulk containers (55-gallon drums, aboveground storage tanks, and underground storage tanks).

The Y-12 Plant underground storage tank program includes seven in-service petroleum tanks. In addition, there are seven active petroleum underground storage tanks at the K-25 Site. At the ORNL there is one active underground storage tank containing heating oil and 22 active underground storage tanks that will be taken out of service or upgraded by 1998. The contents of these tanks was not reported (MMES 1993a).

Table 4.14-5. Projected 1995 low-level waste management activities at the ORR.

Complex	Waste category	Generation rate[b]	Treatment method	Treatment capacity	Storage method	Storage capacity	Disposal method	Disposal capacity
Y-12 Plant	Low-level solid[b]	1,438,680 kg[c] (5,793 m3/yr)	Compaction/ incineration	Offsite	Stored onsite at Y-12 or K-25	See mixed solids	N/A[d]	N/A
	Low-level liquid[b]	565,929 kg (148,186 gal/yr)	Settlement and filtration	20,644m3/yr[e] (5,400,000 gal/yr)	Stored onsite	See mixed liquids	N/A	N/A
K-25 Site	Low-level liquid[f]	Included in mixed	Settlement and filtration	See mixed liquid	None	Not applicable	Not applicable	Not applicable
	Low-level solid[f]	978.7 m3 [g]	Compaction/ smelting	Offsite	Onsite	See mixed[h]	Planned onsite non-metallic Planned offsite metallic	Planned
ORNL	Low-level liquid[f]	2,064.4 m3	Neutralization & precipitation	1.5292M m3 [i]	Stored onsite in underground tanks	573.5 m3	None	Not applicable
	Low-level solid[f]	130 m3 [j]	Compaction	Offsite	Onsite	32,770.8 m3[k]	Onsite burial	Not applicable

a. Sources: Snider (1993); Brown (1994c).

b. 1992 data.

c. Includes 649,429 kg of contaminated scrap metal.

d. N/A = not applicable.

e. West End Treatment Facility and Central Pollution Control Facility.

f. 1991 data.

g. Includes contaminated scrap metal.

h. Does not include 6.9 acre scrap metal storage site.

Table 4.14-5. (continued)

i. NPDES discharge limit for the ORNL Non-rad Wastewater Treatment Facility.

j. Includes scrap metal only. Does not include low-level radioactive waste solid sludge from Process Waste Treatment Facility, or from Sanitary Wastewater Treatment Plant.

k. Solid Waste Storage Area.

Table 4.14-6. Baseline low-level waste management activities as of 1995 at the ORR.

Complex	Waste	Facility number identification	Facility description	Facility storage capacity	Available disposal space
Y-12 Plant	Low-level[b]	9720-12	Low-level waste storage		
			Indoor area	465 m2	Not accepting waste
			Outside area	557 m2	139 m2
		9720-44	Low-level waste storage pad	Not reported	Not reported
		9825-1, 2	Uranium oxide storage vaults I and II	906 m3 (each vault)	544 m3 (each vault)
		None	Contaminated scrap metal storage area	Not reported	5% of area available
		None	Outside low-level waste storage	359 m3	Not reported
		None	Above grade low-level waste storage facility	3,948 m2	3,553 m2

Complex	Waste identification	Facility number	Facility description	Facility storage capacity	Available disposal space
		9720-25	Classified waste storage facility	340 m3	170 m3
		None	Containerized waste storage area (dual use/storage)	2,323 m2	929 m2
K-25 Site	Low-levelc	K-770	Contaminated scrap metal storage yard	31,857 m3	2,230 m3
		K-1035-A	Temporary drum storage	2.5 m3	Varies
		K-1066-H	LLWd storage	3,830 m3	627 m3
		K-1417	Sludge-drum storage yard	8,846 m3	Facility full
		RUBB-2	LLWd storage	138 m3	83 m3
		K-25	Process vaults (dual storage/use facility)	2,469 m3	837 m3
		K-33	Waste piles (dual storage/use facility)	961 m3	24 m3
		K-1232	Container storage area (dual storage/use facility)	42.5 m3	34 m3
ORNL	Low-levelb	7831	Waste compaction facility	Not applicable (treatment facility)	Not applicable (treatment facility)
		7841	Contaminated equipment storage yard	Not reported	Scheduled to undergo closure under RCRAe
		7856	Cask storage site	Not reported	Not reported
		7823A, B, C, D, E	RUBB buildings	Not reported	Not reported
		7824	Waste examinations and assay facility, dual use facility	Not available	Not available
		7879	CH-TRUf/LLWd solids storage facility (dual storage facility)	372 m2	Facility full
		7842	SWSA-6g staging and equipment building	297 m2	Not applicable Facility is a staging area
		None	Tumulus I and II	Not reported	Facilities undergoing closure

a. Sources: PAI Corporation (1993b); PAI Corporation (1994); PAI Corporation (1993a); Turner (1994).

b. 1993 data.

c. 1994 data.

d. LLW = Low-level (radioactive) waste.

e. RCRA = Resource Conservation and Recovery Act.

f. CH-TRU = Contact-handled transuranic waste.

g. SWSA-6 = Solid Waste Storage Area - 6.

Table 4.14-7. Projected 1995 hazardous waste management activities at the ORR.

Complex	Waste category	Generation rate	Treatment method	Treatment capacity	Storage method	Storage capacity	Disposal method	Disposal capacity

Y-12 Plant	Hazardous solid[b]	511,421 kg[c] (846 m3/yr)	None	Not applicable	Staged for shipment	4,741m3 d	Offsite	Not applicable
	Hazardous liquid[b]	767,874 kg[e] (215,492 gal/yr)	Settlement and filtration	See low-level liquid	Tanks	670 yd3 f (136,000 gal)	Offsite	Not applicable
K-25 Site	Hazardous liquid[g]	8,410.6 m3 h	Neutralization/ precipitation	See mixed	Stored for processing	Not applicable	Planned offsite	Not applicable
	Hazardous solid[g]	680.5 m3	Compaction for non-RCRA/TSCA[i] incineration	Offsite	Onsite	See mixed	Planned offsite	Not applicable
ORNL	Hazardous liquid[g]	0.8 m3	Neutralization/ detonation	Not applicable	Tanks	588.7 m3	Offsite	Not applicable
	Hazardous solid[g]	84.1 m3 j	None	Not applicable	Staged for shipment	23,375 gal[k]	Planned onsite/offsite	Planned

a. Sources: Snider (1993); Brown (1994c).

b. 1992 data.

c. Includes 420,192 kg of uncontaminated (radionuclides) asbestos/beryllium oxide (BeO) waste and 42,434 kg of uncontaminated polychlorinated biphenyl waste.

d. Remaining West End Tank Farm sludge storage capacity.

e. Includes 55,624 kg of uncontaminated (radionuclides) polychlorinated biphenyl waste.

f. Liquid Organic Waste Storage Facility OD3, Building 9418-9, and OD9.

Table 4.14-7. (continued)

g. 1991 data.

h. Hydrogen softener blowdown from the steam plant.

i. RCRA = Resource Conservation and Recovery Act; TSCA = Toxic Substances Control Act.

j. Includes polychlorinated biphenyls and asbestos.

k. Hazardous Waste Storage Facility.

Table 4.14-8. Baseline hazardous waste management activities as of 1995 at the ORR.

Complex	Waste identification	Facility number	Facility description	Facility storage capacity	Available disposal space
Y-12 Plant	Hazardous[b]	None	Interim reactive waste treatment area (open burning)	Not applicable	Not applicable
		9720-45	Organic liquid storage facility	Two 3,000-gal tanks Four 6,500-gal tanks 1,000, 55-gal drums	Variable
		9720-9	Mixed and PCB[c] storage area (dual storage/use)	311 m3	62 m3
		9720-31	RCRA[d] staging and storage facility (dual storage/use)	37,000 gallons	9,250 gallons
		9720-58	RCRA[d] and PCB[c] container storage area (dual storage/use)	Not reported	Not reported
		9811-1	Waste oil tank storage Area OD-7 (dual storage/use)	Two 30,000-gal tanks One 10,000-gal tank Two 3,000-gal tanks	38,000 gallons
		9811-8	Waste oil solvent drum storage	1,000 55-gal	

			facility, OD-8 (dual storage/use)	drums/containers	Not reported
		9811-8	Organic liquid storage area, OD-9 (dual storage/use)	Five 40,000-gal tanks Thirty-five 55-gal drums	50,480 gallons (projected to be used until the year 2010)
		9404-7	PCBc storage facility	334 m2	84 m2
		None	East Chestnut Ridge Waste Pile (dual use/storage facility)	Not reported	Not reported
K-25 Site	Hazardous/ mixed	K-25	Process vaults (dual storage/use facility)	6,810 m3	1,282 m3
		K-711	Container storage building (dual storage/use facility)	234 m3	188 m3
		K-1025C	Container storage (dual storage/use facility)	7 m3	1 m3
		K-1036A	Container storage facility (dual storage/use facility)	134 m3	44 m3
Complex	Waste identification	Facility number	Facility description	Facility capacity	Available disposal storage space
		K-1202	Storage tanks (dual storage/use facility)	108 m3	76 m3
		K-1302	Compressed gas cylinder storage (dual storage/use facility)	0.6 m3	Facility full
		K-1420A	Hazardous waste storage tank (dual storage/use facility)	108 m3	108 m3
		K-1425	Container storage/tank management units (dual storage/use facility)	529 m3	357 m3
		K-726	Container storage building (dual storage/use facility)	86 m3	Facility full
		K-33	TSCAf (dual storage/use facility)	961 m3	24 m3
ORNL	Hazardousb	7659-A	Gas cylinder venting facility	Not applicable (venting facility)	Not applicable
		7667	Chemical waste detonation facility	Not applicable (treatment facility)	Not applicable (treatment facility)
		7507	PCBsg, liquids and solids storage facility	31 m3	Facility full
		7651	Used oil storage facility	27 m3	13 m3
		7652	Hazardous waste storage facility	57 m3	8.5 m3
		7653	Chemical waste storage facility	60 55-gal drums	9 55-gal drums

a. Sources: PAI Corporation (1993b); PAI Corporation (1994); PAI Corporation (1993a).

b. 1993 data.

c. PCB = Polychlorinated biphenyl.

d. RCRA = Resource Conservation and Recovery Act.

e. 1994 data.

f. TSCA = Toxic Substances Control Act.

g. PCB = Polychlorinated biphenyl.

Table 4.14-9. Projected 1995 industrial solid waste management activities at the ORR.

Complex	Waste category	Generation rate[b]	Treatment method	Treatment capacity	Storage method	Storage capacity	Disposal method	Disposal capacity
Y-12 Plant	Industrial solid[b]	5,554,873 kg (48,518 m3/yr)	None	N/A	None	N/A	Landfill (onsite)	5.3522M[c] m3[d]
K-25 Site	Industrial solid[e]	3,899.5 m3	None	Not applicable	None	Not applicable	Y-12 landfill	5.3522M[c] m3[f]
	Other solid[e]	5,046.4 m3[g]	Compaction	Not applicable	None	Not applicable	Y-12 landfill	See industrial solid
ORNL	Industrial solid[e]	13 m3	None	Not applicable	None	Not applicable	Y-12 landfill	5.3522M[c] m3[f]
	Other solid[e]	30.6 m3[h]	None	Not applicable	None	Not applicable	Y-12 landfill	See industrial solid

a. Sources: Snider (1993); Brown (1994c); PAI Corporation (1994); PAI Corporation (1993a).

b. 1992 data.

c. M = million

d. New sanitary landfill to open in 1994.

e. 1991 data.

f. Wastes are disposed of at the Y-12 Plant Sanitary Landfill.

g. Includes construction/demolition spoil and scrap metal.

h. Includes construction/demolition spoil; scrap metal estimates not available.

Table 4.14-10. Baseline industrial solid waste management activities as of 1995 at the ORR. ,b

Complex	Waste identification	Facility number	Facility description	Facility storage capacity	Available disposal space
Y-12 Plant	Industrial solid	None	New salvage yard	4,046.9 m2	1,619 m2
		None	Industrial landfill IV (classified waste landfill)	Not reported	Estimated useful life of the landfill is until the year 2034
		9983-44	Industrial landfill II	Storage capacity depleted	Storage capacity depleted
		None	Spoil Area 3 (construction debris)	Facility closed	Facility closed
		9720-25	Classified waste storage (dual use facility)	Not applicable (nonhazardous solid staging area)	Not applicable waste
K-25 Site	Industrial solid[c]				
ORNL	Industrial solid[c]				

a. Source: PAI Corporation (1993b).

b. 1993 data.

c. Wastes are disposed of at the Y-12 Plant Sanitary Landfill.

In addition, diesel fuel and gasoline, used to fuel site service and construction vehicles, are stored in bulk containers (55-gallon drums, aboveground storage tanks, and underground storage tanks).

The Y-12 underground storage tanks program includes seven in-service petroleum tanks. In addition, there are seven active ptroleum underground storage tanks at the

K-25 Site. At the ORNL there is one active underground storage tank containing heating oil and 22 active underground storage tanks that will be taken out of service or upgraded by 1998. The contents of these tanks was not reported (MMES 1993a).

5. ENVIRONMENTAL CONSEQUENCES

5.1 Overview

This chapter describes the potential environmental consequences from the construction and operation of spent nuclear fuel (SNF) facilities at the Oak Ridge Reservation (ORR) under the Centralization and Regionalization Alternatives. Potential environmental consequences are assessed to the extent necessary to support a programmatic decision concerning the siting of the proposed SNF facilities. More detailed considerations of potential environmental consequences would be performed as necessary prior to initiating construction or operation of the facilities.

Impacts on the operation of the current facilities at ORR that create or store SNF are discussed in Chapter 3.

5.2 Land Use

The proposed site for SNF activities is in the eastern portion of the West Bear Creek Valley area, located in the western portion of the ORR. The SNF program's land requirements are assumed to be 90 acres (0.36 square kilometer), including all facilities and buffer areas. The majority of the land in the West Bear Creek Valley Area can be characterized as vacant, unused, and developable.

5.2.1 Centralization Alternative

Use of the West Bear Creek Valley area of the ORR for program activities would be consistent with the current land use and land use policies and plans for that area. The current land use designation for this area is Natural Areas, a generic category that includes all lands within the ORR not under any other specific land use designation (DOE 1993a). Use of this area for program activities would also be consistent with proposed future land uses as set forth in the ORR Site Development Plan (MMES 1989).

Future land uses proposed for the area of Roane County adjacent to the ORR near the proposed SNF site are low-density residential and public/semi-public uses (Roane County Regional Planning Commission 1992). These low intensity uses would be compatible with development in the western portion of the ORR.

Use of the West Bear Creek Valley site for the placement of SNF facilities may result in irreversible and irretrievable impacts to land use in that area by precluding all but waste management-type uses in the future. However, the placement of SNF facilities at this location would be consistent with U.S. Department of Energy's (DOE's) 1994 future land use plan, which designates the West Bear Creek Valley site for these uses (MMES 1989). Therefore, no mitigation measures are proposed.

5.2.2 Regionalization Alternative

As under the Centralization Alternative, land use impacts resulting from the Regionalization Alternative would not be expected to be significant. Impacts would be similar in character to those described for the Centralization Alternative.

5.3 Socioeconomics

Socioeconomics as addressed in this programmatic environmental impact statement (EIS) encompasses the interaction of economic, demographic, and social conditions. Economic consequences (e.g., technology requirements for operation of an SNF management facility) affect business activities, market structures, procurement methods, and dissemination of commodities within and between regions. Demographic consequences (e.g., in-migration of specialized human resources to support the SNF management program) affect size, distribution, and composition of the population, labor force, and the housing market in the regions. Social consequences (e.g., capacity modifications of public infrastructure to support SNF activity) affect the overall quality of life enjoyed by the residents of a community (Murdock and Leistritz 1979). These conditions are potentially affected either directly or indirectly by actions proposed under the DOE SNF Management Program.

The significance of actions and their intensity are relative to the affected region. A region can be described as a dynamic socioeconomic system, where physical and human resources, technology, social and economic institutions, and natural resources interrelate to create new products, processes, and services to meet consumer demands. The measure of a region's ability to support these demands depends on its ability to respond to changing economic, demographic, and social conditions.

Potential socioeconomic effects are addressed only to the extent that they are interrelated with the natural or physical environment (CFR 1993c). Direct effects include those impacts caused by the action and occurring at the same time and place. Indirect effects include those impacts caused by the action that are later in time or farther removed in distance, but are still reasonably foreseeable (i.e., offsite) (CFR 1993b).

Socioeconomic effects are quantified for regional economic activity and population. Potential impacts to individual communities such as public infrastructure and housing are discussed qualitatively to address programmatic issues.

Economic projections include direct and indirect jobs. Direct jobs are those jobs needed to construct or support operation of the SNF management complex at ORR. Indirect jobs are created throughout the regional economy within the Region of Influence as a result of procurement for materials, services, and other commodities; and induced effects from consumer spending. These direct and indirect impacts reflect both construction and operation phase demands that may occur concurrently or independently throughout the project planning period. Indirect jobs were projected using parameters from the U.S. Bureau of Economic Analysis Regional Input-Output Modeling System.

Two scenarios were analyzed to account for two potential distributions of the SNF facility construction efforts. The construction effort consists of fabricating various structures, each with its own construction labor need and a duration of either three or five years. The Peak Scenario accelerates the construction labor requirements into the first two years of construction. The Average Scenario averages the labor requirements of a structure for the duration of construction. The total construction effort for all structures, in labor years is the same for each scenario. Therefore, for structures with a three year construction duration, the Peak Scenario has high labor needs for the first two years and then a substantial reduction for the third year, while the Average Scenario has a constant labor requirement for the three years. Likewise, for structures with a five year construction duration, the Peak Scenario has a high labor need for the first two years, then a lower need for the remaining three years, while the Average Scenario has a constant requirement for all five years. Because the total construction labor years for each structure is the same for both scenarios, the Average Scenario will have a lower requirement than the Peak Scenario in the first two years, then will have a higher requirement then the Peak Scenario in the remaining construction years.

Regional population projections reflect the potential change in population resulting from an increase in regional economic activity. Detailed assumptions regarding in-migration associated with SNF Management Program were not developed given the programmatic scope of the analysis. Potential in-migration effects resulting from direct job creation are presented qualitatively where appropriate.

5.3.1 Centralization Alternative

The upper and lower bounds of construction and operations related jobs generated from implementation of the Centralization Alternative from 1995 to 2005 are illustrated in Figure 5.3-1 and tabulated in Table 5.3-1. In the initial phases, the Centralization Alternative may create 90 jobs (25 direct, 65 indirect) beginning in 1995 and continuing through the year 1999 to support project planning, engineering design, and environmental permitting and compliance. Construction is expected to begin in the year 2000, requiring a total of 4,352 direct jobs (7,1232 indirect jobs). In that year and 2001, the Peak Scenario requires 1,587 construction laborers, while the Average Scenario needs 1,346. There is no operational labor required for this time period. In 2002 after two years of construction, the Peak Scenario decreases its construction labor requirements to 928 workers, while the Average Scenario maintains its 1,346 laborers. Additionally, 300 operational personnel are needed, raising the total of SNF workers to 1,228 for the Peak Scenario and 1,646 for the Average Scenario. By 2003, the buildings with three year construction durations have been completed; therefore, both the Peak and Average Scenario construction labor requirements decline to 125 and 157, respectively. Operation labor

Figure 5.3-1. Total employment effects- ORR Centralization Alternative.

Table 5.3-1. Socioeconomic effects - Centralization of SNF at Oak Ridge Reservation.

	Time period					
Years	1995-1999	2000, 2001	2002	2003	2004	2005 +
Operations						
Direct jobs	25	0	300	300	487	800
Indirect jobs	65	0	780	780	1,265	2,079
Total jobs	90	0	1,080	1,080	1,752	2,879
Construction						

Direct jobs						
Peak	0	1,587	928	125	125	0
Average	0	1,346	1,346	157	157	0
Indirect jobs						
Peak	0	2,597	1,519	205	205	0
Average	0	2,203	2,203	257	257	0
Total jobs						
Peak	0	4,184	2,447	330	330	0
Average	0	3,549	3,549	414	414	0
Total						
Direct jobs						
Peak	25	1,587	1,228	425	612	800
Average	25	1,346	1,646	457	644	800
Indirect jobs						
Peak	65	2,597	2,299	984	1,470	2,079
Average	65	2,203	2,983	1,036	1,522	2,079
Total jobs						
Peak	90	4,184	3,527	1,408	2,082	2,879
Average	90	3,548	4,629	1,493	2,166	2,879
Population Change						
Peak	82	4,366	(1,001)	(3,214)	1,022	2,011
Average	82	3,688	1,640	(4,759)	1,022	1,797

requirements remain at 300 workers. Total SNF labor requirements are 425 workers for the Peak Scenario and 457 for the Average Scenario. In 2004, construction labor needs for both scenarios remains at their previous level, but operational personnel increase. Total SNF labor requirements are 612 workers in the Peak Scenario and 644 workers in the Average Scenario. By 2005, all construction has been completed and operational personnel have increased to the full staff labor requirement of 800 workers.

The peak scenario reaches it maximum construction labor with 1,587 direct jobs (4,184 total jobs created) over a 2-year period from years 2000 through 2001. The average scenario would have its maximum construction labor with 1,346 direct jobs (3,549 total jobs created) from 2000 through 2002.

Ancillary operation (Table 5.3-1) activity associated with the Centralization Alternative will begin in the year 2002; the initial operations might create approximately 1,080 phase-related jobs (300 direct, 780 indirect). Additional operation activity would also begin, creating an additional 187 phase-related jobs (485 indirect jobs). The remaining operation activities are expected to start in 2005, after construction is finished, creating a total of 2,879 phase-related jobs (800 direct, 2,079 indirect), and the jobs will continue through 2035.

Regional businesses and the workforce will benefit from increased competition for contract procurements and jobs associated with SNF Centralization Alternative. Most of this activity is anticipated to be captured by Anderson, Knox, and Roane counties, with a small share occurring in Loudon County. The impact to the regional economy, however, only represents a portion of the total economic activity generated by the Centralization Alternative. For instance, specialized materials purchases and technology acquisition may occur outside Tennessee. The economic activity occurring outside the region might result in economic benefits for that region. This indirect effect is not captured by this analysis since it occurs outside of the Region of Influence as defined in Section 4.3.

Most of the population change in the Region of Influence above the baseline forecast will be driven by the in-migration of labor and households to support SNF management activities at ORR. It is likely that most of the operation jobs will be filled by SNF personnel relocating from other DOE sites where SNF inventories were stored prior to shipments to ORR. These personnel would be familiar with the processes, technologies, and research involved with SNF operations elsewhere. Other operational jobs not associated with SNF management will probably be filled by the regional labor force. The regional labor force would be likely to fill the demand for construction jobs, except for specialized tasks.

To assess potential population and housing impacts, an in-migration rate per job was estimated using a ratio between forecasted employment and population figures (Table 4.3-1). This ratio was applied to the number of total (direct and indirect) jobs created by SNF management activities at ORR, giving the total estimated number of persons migrating into the Region of Influence per job created (Table 5.3-1).

With initial operation in 1995 under both scenarios, a total of 82 persons will migrate into the Region of Influence. The number of persons migrating into the Region of Influence would be at its largest when construction starts, for the years 2000 through 2001; (a total of 4,366 in-migrants for the peak scenario and 3,688 for the average scenario). For the years 2002 and 2003, after most of the construction has finished, people might migrate out of the Region of Influence. The number of in-migrants might increase as more of the SNF management operations start in the years 2004 and 2005. After the year 2005, in-migration due to SNF management activities would cease due to the fact that SNF management activities would not create any more jobs.

Assuming one housing unit per household, and an average family size of 2.6 persons per family (U.S. Department of Commerce 1991), the number of houses demanded in 1995, when preliminary operations start, might be 32. Between the year 2000 and 2002, a total of 1,679 housing units might be demanded. Even though this demand is only a temporary demand, the Region of Influence may have difficulty providing new housing during this time period. By the year 2003 and 2004, however, there might be a surplus of 1,236 housing units due to the phasing out of construction. In 2005, once SNF operational activities are under way, there will be a demand for 1,167 housing units associated with SNF management activities.

The greatest impact to the Region of Influence housing market may occur between the years 2000 and 2002, when construction starts. The demand for housing during the SNF facility construction period would be for transitional housing. While the population in the Region of Influence under baseline conditions has historically been growing and is projected to grow at less than 1 percent annually, recent vacancy rates for housing in the Region of Influence have been low (Census 1982, 1991). Therefore the in-migration associated with SNF construction might cause shortages in the housing market, and might cause shortages in construction supplies. However, due to decreasing employment levels on ORR between 1990 and 1999 (Section 4.3.1.5), additional housing units above the baseline may be available, thus reducing the potential strain on the housing market. Since construction will only be temporary, there may be excess capacity in the regional infrastructure when all SNF management operations begin in 2005.

5.3.1.1 Potential Public Service and Education Impacts. Given the population growth

associated with the SNF Management Program, increases in capital expenditure may be required to meet the increased demand of housing utilities, including electricity generation, wastewater treatment, and water (see Section 5.13), transportation infrastructure (see Section 5.11), and education or service levels, assuming current conditions are constant through the analysis.

Assuming that the Centralization Alternative would be an addition to the ORR's current operations, security and fire protection on the site would need to be investigated at a minimum to determine whether or not current capacity could accommodate the requirements of the SNF Management Program.

5.3.2 Regionalization Alternative

Socioeconomic impacts resulting from the Regionalization Alternative are expected to be similar to the Centralization Alternative. The construction and operation cycles for each alternative would be the same; therefore, the same issues identified for the Centralization Alternative would apply. Labor requirements may be slightly reduced for the Regionalization Alternative. Although the volume of SNF stored would be less for the Regionalization Alternative, an economy of scale occurs for both alternatives, so that differences in labor and capital between the two alternatives would be minimized.

5.3.3 Mitigation Measures

5.3.3.1 Coordination with Local Jurisdictions. To reduce construction- and operation-

related impacts, possible coordination with local communities could address potential impacts from increased labor and capital requirements. The knowledge of the extent and effect of growth due to SNF management activities could greatly enhance the ability of affected jurisdictions to plan effectively. Effective planning would address changes in levels of service for housing, infrastructure, utilities, transportation, and public services and finances.

5.3.3.2 Enhance Labor Force Availability. To alleviate potential impacts associated with

the in-migration of labor, local labor force availability could be increased through various employment training and referral systems. The goal of these systems would be to reduce the potential for in-migration of labor to support SNF management activities.

5.4 Cultural and Paleontological Resources

5.4.1 Centralization Alternative

Under the Centralization Alternative, the proposed construction area for the SNF facilities is not expected to exceed 100 acres. There are no known historical, archeological, paleontological or Native American traditional sites in the proposed area (Fielder 1975). No impacts to cultural or paleontological resources are expected due to ground disturbance, noise, or air emissions during construction or operation of the SNF facilities. Consultation with the Tennessee State Historic Preservation Officer prior to project implementation is required by section 106 of the National Historic Preservation Act.

5.4.2 Regionalization Alternative

Under the Regionalization Alternative, the location of the SNF facilities would remain the same, but would be reduced in area. As with the Centralization Alternative, impacts are not anticipated.

5.5 Aesthetics and Scenic Resources

5.5.1 Centralization Alternative

When fully constructed and under operation, the proposed SNF facilities associated with the Centralization Alternative would consist of a series of buildings set within a 90-acre site. The maximum height of the buildings contained at the site would not exceed 42 feet above ground level, or two to three stories. The entrance to the site and security fencing will be visable to traffic on Bear Creek Road.

Since the buildings would be set into the south face of Pine Ridge, between Pine Ridge and Chestnut Ridge, the site would not be visible from areas outside the reservation, with the possible exception of a limited section of Gallaher Road on the west side of the Clinch River, looking east along Bear Creek Valley (TVA 1987). However, since the approximate distance from the boundary of the reservation to the proposed location is in excess of 2 miles, and includes hilly terrain and heavy vegetation, public views looking on to the site from off-site are not expected to be affected. Impacts to aesthetics and scenic resources on and off ORR are not anticipated.

5.5.2 Regionalization Alternative

Under the Regionalization Alternative, proposed SNF facilities are reduced in area and intensity of operations, and environmental effects to aesthetics and scenic resources would be less than those under the Centralization Alternative. Therefore, adverse environmental impacts from the Regionalization Alternative are also not anticipated.

5.6 Geologic Resources

This section describes any incremental or additional impacts on geology and geologic resources that might result from the construction and operation of the new facilities associated with the storage of SNF at the ORR.

For the most part, geologic impacts from construction activities would be limited to soil disturbance, although in some areas, ripping or blasting of limestone, dolomite, or chert layers might be required. Since no extensive or unique geologic or mineral resources are known to occur on the West Bear Creek Valley site, impacts to geologic resources would not be expected.

Because previously undisturbed areas would be used for new construction, some soil impacts from siting SNF facilities at the West Bear Creek Valley site would occur as a result of grading. Potential impacts from sediment runoff generated during construction activities would be minimized by implementation of soil erosion and sediment control measures. During operations, impacts to soil resources would be controlled by the planting or landscaping of land surfaces not covered by pavement and buildings.

Major seismic activity and associated mass movement and subsidence are unlikely to occur during the construction or operation phases, because although ground-shaking has occurred at the ORR due to earthquakes in other parts of the country, faults in the area have not been active since the late Paleozoic.

5.7 Air Resources

The proposed SNF management facility would be composed of a wet and dry storage facility and a technology development facility, with construction to take place in the calendar years 2000-2004. Air quality is assessed for construction and operation with regard to radiological and nonradiological air emissions. This section characterizes the impacts and expected air quality effects resulting from an SNF facility. This section also discusses the quantitative impacts under the Regionalization Alternative. The Centralization Alternative qualitative impacts are compared with the regionalization impacts in order to determine exceedances, if any, of existing local and Federal standards for both alternatives.

5.7.1 Releases

Emissions of radiological and nonradiological air pollutants might result from the construction and operation of a SNF management facility. These emissions might include airborne radionuclides, criteria pollutants, and hazardous air pollutants.

The impact of air emissions from construction activities might include criteria air pollutants of particulate matter (fugitive dust) primarily from the moving of soil, and exhaust emissions of particulate matter with an aerodynamic diameter equal to or less than 10 microns (PM10); carbon monoxide; sulfur dioxide; volatile organic compounds; and nitrogen dioxide from earth-moving and equipment-handling machinery and equipment. During construction, a small increment in traffic volume above existing levels might result in a small increase in air pollutant emissions. (Section 5.11 discusses the level of traffic activity projected for the construction and operation phases of the SNF facility.)

During operations, the transport of SNF within the ORR from points of generation or storage sites to the disposal site would result in emissions of criteria air pollutants from various vehicles as well. Some emissions of air pollutants from worker vehicles would also occur both within and beyond the ORR.

5.7.1.1 Radiological Emissions. There are no expected contributions to radiological air

emissions during the construction phases of the proposed SNF management facility. During operations, the facility would be expected to generate negligible radiological emissions. The potential radiological emissions associated with the proposed SNF management facility and those associated with the baseline are presented in Table 5.7-1 by isotope.

5.7.1.2 Nonradiological Emissions. The construction phase of the SNF facility for the

Receipt/Storage Facility and Canning Factory is estimated to be complete in about 8-10 years. Short-term emissions, such as fugitive dust and heavy equipment exhaust emissions, would be generated temporarily, and would only affect receptors close to construction areas. Fugitive dust emissions would be minimized by watering. Under the operational phase of the SNF management facility, criteria and hazardous air pollutants might be emitted. Table 5.7-2 lists total expected annual emissions associated with the SNF storage facility. These nonradioactive emissions are primarily from the technology development facility and were estimated based on a previous design for a similar facility proposed at INEL.

Table 5.7-1. Isotopic release additions due to SNF management facility presence (Ci/yr) at ORR.

	(Baseline) ORR	(SNF) ISF	ORR+ ISF
Hydrogen-3	2.1 x 103	7.9 x 10-1	2.1 x 103
Beryllium-7	8.9 x 10-6	0.0 x 100	8.9 x 10-6
Carbon-14	0.0 x 100	1.2 x 100	1.2 x 100
Potassium-40	1.0 x 10-3	0.0 x 100	1.0 x 10-3
Manganese-54	0.0 x 100	2.2 x 10-8	2.2 x 10-8
Cobalt-60	3.0 x 10-5	4.2 x 10-8	3.0 x 10-5
Bromine-82	1.0 x 10-5	0.0 x 100	1.0 x 10-5
Krypton-83M	7.3 x 101	0.0 x 100	7.3 x 101
Krypton-85	0.0 x 100	1.0 x 104	1.0 x 104
Krypton-85M	1.7 x 102	0.0 x 100	1.7 x 102
Krypton-87	3.5 x 102	0.0 x 100	3.5 x 102
Krypton-88	4.9 x 102	0.0 x 100	4.9 x 102
Krypton-89	6.3 x 102	0.0 x 100	6.3 x 102
Strontium-90	1.2 x 10-4	3.3 x 10-6	1.2 x 10-4
Yttrium-90	1.2 x 10-4	3.3 x 10-6	1.2 x 10-4
Technetium-99	6.1 x 10-2	0.0 x 100	6.1 x 10-2
Ruthenium-106	4.4 x 10-4	1.1 x 10-5	4.5 x 10-4
Antimony-125	0.0 x 100	3.4 x 10-4	3.4 x 10-4

Iodine-129	3.1 x 10-4	1.0 x 10-1	1.0 x 10-1
Iodine-131	1.2 x 10-1	0.0 x 100	1.2 x 10-1
Iodine-132	1.4 x 100	0.0 x 100	1.4 x 100
Iodine-133	6.5 x 10-1	0.0 x 100	6.5 x 10-1
Iodine-134	2.1 x 10-2	0.0 x 100	2.1 x 10-2
Iodine-135	1.2 x 100	0.0 x 100	1.2 x 100
Xenon-133	8.8 x 102	0.0 x 100	8.8 x 102
Xenon-133M	2.7 x 101	0.0 x 100	2.7 x 101
Xenon-135	2.8 x 101	0.0 x 100	2.8 x 101
Xenon-135M	1.6 x 102	0.0 x 100	1.6 x 102
Xenon-138	8.5 x 102	0.0 x 100	8.5 x 102
Cesium-134	6.3 x 10-7	6.2 x 10-8	6.9 x 10-7
Cesium-137	7.0 x 10-4	4.8 x 10-5	7.5 x 10-4
Cesium-144	1.2 x 10-6	0.0 x 100	1.2 x 10-6

	(Baseline) ORR	(SNF) ISF	ORR+ ISF
Barium-140	1.0 x 10-4	0.0 x 100	1.0 x 10-4
Lanthanum-140	1.4 x 10-6	0.0 x 100	1.4 x 10-6
Europium-152	4.4 x 10-11	0.0 x 100	4.4 x 10-11
Europium-154	5.9 x 10-6	0.0 x 100	5.9 x 10-6
Europium-155	3.0 x 10-6	0.0 x 100	3.0 x 10-6
Osmium-191	2.3 x 10-2	0.0 x 100	2.3 x 10-2
Lead-212	1.6 x 100	0.0 x 100	1.6 x 100
Thorium-228	1.5 x 10-3	0.0 x 100	1.5 x 10-3
Thorium-230	7.4 x 10-4	0.0 x 100	7.4 x 10-4
Thorium-232	3.0 x 10-5	0.0 x 100	3.0 x 10-5
Protactinium-234	1.2 x 10-3	0.0 x 100	1.2 x 10-3
Uranium-234	7.2 x 10-2	0.0 x 100	7.2 x 10-2
Uranium-235	2.6 x 10-3	0.0 x 100	2.6 x 10-3
Uranium-236	1.9 x 10-4	0.0 x 100	1.9 x 10-4
Uranium-238	4.1 x 10-2	0.0 x 100	4.1 x 10-2
Neptunium-237	1.1 x 10-4	0.0 x 100	1.1 x 10-4
Plutonium-238	6.1 x 10-4	0.0 x 100	6.1 x 10-4
Plutonium-239	1.3 x 10-4	0.0 x 100	1.3 x 10-4
Plutonium-240	0.0 x 100	0.0 x 100	0.0 x 100
Americium-241	1.4 x 10-5	0.0 x 100	1.4 x 10-5
Curium-244	2.0 x 10-4	0.0 x 100	2.0 x 10-4

a. Source: Johnson, V. (1994).

Cm241 with 35 day half-life included with AM241 with 458 yr half-life.
Os194 with 8.0 yr half-life decays to Ir194 with 17.4 hr half-life, then to P1194 which is stable.
ISF: Interim Storage Facility.

Table 5.7-2. Total annual nonradioactive emissions for the SNF management facility at ORR.

Criteria pollutants	Release rate (kg/yr)
Carbon monoxide	1.7 x 103
Particulate matter, PM10b	1.0 x 10-3
Nitrogen oxides	5.5 x 103
Sulfur dioxide	1.3 x 102
Lead	5.0 x 10-9
Hazardous air pollutants	
Selenium compounds	1.6 x 10-4
Mercury compounds	5.1 x 10-1
Chlorine	3.5 x 103
Hydrogen fluoride	1.6 x 101
Cadmium compounds	2.9 x 10-7
Cobalt, chromium, antimony, and nickel compounds	2.0 x 10-10

a. Source: Johnson, V. (1994).

b. It is assumed that PM10 (particulate matter less than 10 microns in diameter) data are total suspended particulate data.

5.7.2 Air Quality

5.7.2.1 Radiological. The GENII Environmental Transport and Dose Assessment Model,

along with 1992 Y-12 west meteorological data and 1992 source terms (Table 5.7-1), was used to calculate the effective dose equivalent for the year 2005. A population of 988,754 persons within 80 kilometers (50 miles) is estimated. A radiation background level of 306 millirem per year is used.

Based on model results, 1 year of operation at the SNF management facility might result in a calculated dose of 9.5 millirem per year to the maximally exposed member of the public. This dose is below the National Emission Standards for Hazardous Air Pollutants limit of 10 millirem per year and is 3.1 percent of the natural background radiation received by the average person near the ORR.

The annual population dose from operation in the year 2005 was calculated to be 5.7 x 101 person-rem. The population dose from operation of this option in 2005 is approximately 2.1 x 10-2 percent of the dose received by the surrounding population from natural background radiation.

Table 5.7-3 summarizes the effective dose equivalents for the maximum boundary dose and to the population with 80 kilometers (50 miles) of the proposed SNF facility. Compared to the background radiation, these increased doses are very small. The total doses are well within the regulatory limits.

5.7.2.2 Nonradiological. The Industrial Source Complex Short-Term Air Dispersion

model was used with 1992 meteorological data from the Y-12 west meteorological monitoring station at ORR to determine pollutant concentrations resulting from the centralization portion of nonradiological emissions listed in Table 5.7-2. An emissions baseline was established to characterize conditions at ORR using actual emission rates (MMES 1993a). It is also assumed that 1995 operations at the ORR will result in the same baseline nonradiological emissions as the 1992 operations at the ORR. The results of modeling are presented in Table 5.7-4, where the existing ORR site contribution concentration is compared to the existing DOE site contribution concentration plus the proposed SNF contribution. Table 5.7-5 presents the annual maximum concentration for hazardous air pollutants for offsite receptors. These concentrations are used in Section 5.12 for calculation of health effects. The increases in pollutant concentrations from the proposed action are negligible in magnitude. The concentrations of nonradiological air pollutants from operation of the SNF facilities, under that alternative, and from existing sources would remain within all applicable regulatory guidelines.

If a Regionalization Alternative SNF facility is operated at the ORR, the incremental contribution to maximum concentrations of pollutants would be less than for the Centralization Alternative. The concentrations of nonradiological air pollutants from operation of the SNF facilities, under this alternative, and from existing sources would remain within all regulatory guidelines.

Table 5.7-3. Summary of effective dose equivalents to the public from ORR operations and the proposed SNF management facility.

	Maximally exposed individual dosea	Collective dose to population within 80 km of ORR sources
Dose	9.5 mrem per yearb	5.7 x 101 c
Location	Site boundary 1.2 km SW of ORR storage facility	9.1 x 105 people within 80 km of SNF storage facility
NESHAPb standard	10 mrem per year	-
Percentage of NESHAP	95	-
Natural background dose	306 mrem	2.79 x 105 person-rem
Percentage of natural background dose	3.1	2.1 x 10-2

a. The maximum boundary dose is the hypothetical individual exposed continuously during the year at ORR boundary located 1.2 km SW from the SNF site.

b. The SNF management facility contributes 6.2 mrem to this dose.

c. The SNF management facility contributes 5.2 person-rem to this dose.

NESHAP: National Emission Standards for Hazardous Air Pollutants.

km: kilometer

mrem: millirem

Note: Effective dose equivalents computed using GENII (PNL 1988).

5.8 Water Resources

Construction and operation of SNF management facilities could potentially affect water resources. Potential environmental impacts to surface water and groundwater resources during construction include depletion of water supplies, floodplain encroachment, and surface water sedimentation from erosion runoff occurring after land clearing. Potential normal operational impacts would include depletion of water supplies, and diminished water quality resulting from wastewater discharges from normal operations.

Impacts are analyzed for the Centralization Alternative, which would cause the most impacts to water resources at the ORR, if chosen. However, for the Centralization Alternative, no significant impacts are identified with respect to water resources issues. Therefore, no significant impacts are expected from the Regionalization Alternative as the Centralization Alternative is the bounding case.

Table 5.7-4. Comparison of baseline concentrations with most stringent applicable regulations and guidelines at ORR and proposed SNF management facility plus current operations.

Criteria pollutant	Averaging time	Most stringent regulation or guidelinea (-g per m3)	Total existing maximum concentrationb (-g per m3)	Total projected maximum concentration including SNF (-g per m3)	Increase in maximum concentration (-g per m3)
Carbon monoxidec	8-hour	10,000	6.9	6.9	0
	1-hour	40,000	24.1	33.5	9.4
Nitrogen dioxide	Annual	100	2.1	2.7	0.6
Lead	Calendar quarter	1.5	d	3.7 x 10-12	3.7 x 10-12
PM10e	Annual	50	12.0	12.0	0
	24-hour	150	97.9	97.9	0
Sulfur dioxide	Annual	80	29.29	29.34	0.05
	24-hour	365	177.8	178.0	0.2
	3-hour	1,300	401.5	401.5	0
Total suspended particulates	Annual	50a	36.0	36.0	0
	24-hour	150a	116.9	116.9	0
Hydrogen fluoride (as fluorides)	30-day	1.2a	0.06	0.06	0
	7-day	1.6a	0.03	0.03	0
	24-hour	2.9a	d	f	f
	8-hour	3.7a	d	f	f
Hazardous air pollutants					
Selenium	8-hour	20	d	2.18 x 10-7	2.18 x 10-7
Mercury compounds	8-hour	0.5	d	2.18 x 10-3	2.18 x 10-3
Chlorine compounds	8-hour	150	d	1.52	1.52
Cadmium compounds	8-hour	5	d	1.81 x 10-9	1.81 x 10-9
Cobalt, chromium, antimony, and nickel compounds	8-hour	5	d	5.5 x 10-10	5.5 x 10-10

a. State standard.

b. Includes background concentration plus existing DOE facilities impact concentration. This is the baseline concentration.

c. Existing maximum and projected maximum did not occur in the same location.

d. Zero release (no sources indicated).

e. It is assumed that PM10 (particulate matter less than 10 microns in diameter) data are total suspended particulate data.

f. Not estimated because the potential release is negligible.

Table 5.7-5. Calculated annual maximum concentrations for hazardous air pollutants at ORR for offsite receptors.

Hazardous air pollutant	Maximum average concentration(-g/m3)
Selenium compounds	8.85 x 10-8
Mercury compounds	8.85 x 10-4
Chlorine compounds	0.62
Hydrogen fluoride	1.53 x 10-3
Cadmium compounds	7.35 x 10-10
Cobalt, chromium, antimony and nickel compounds	2.21 x 10-10

a. Offsite includes public access roads within the ORR. All impacts from proposed source only. No hazardous air pollutant emissions information available for existing sources.

5.8.1 Surface Water Quantity

The ORR currently receives its water supply from the Clinch River basin. Construction and operation of SNF management facilities would have very minimal impact on the quantity of water in the river and in local surface streams.

Construction of SNF management facilities would require some water consumption. However, the amount of water required would not significantly affect the Clinch River water level.

Stormwater runoff associated with both the construction and operation of SNF facilities is expected to have a negligible impact on surface water quantity. During construction, standard stormwater management techniques would be employed to attenuate runoff. A site drainage and stormwater management system consisting of perimeter drainage ditches and a retention pond would be included as part of SNF operations (Johnson, V. 1994). This system would provide for runoff and erosion control, which could otherwise affect receiving water courses or SNF operations.

As discussed in Section 4.8.1, analysis of available data indicates that the proposed SNF management facilities would be sited outside the 500-year floodplain. The SNF management facilities would be located and constructed to minimize any floodplain impact, as required by Executive Order 11988 (Floodplain Management) and DOE Orders. Site-specific surveys would be performed to more accurately determine precise locations of flooding elevations.

Operation of SNF management facilities would require approximately 9,863 gallons (37,335 liters) of water per day. This would mean that an additional 3.6 million gallons (13.6 million liters) of water would be used at the ORR per year. This figure is significantly less than the minimum monthly release for 1992 which was 3.5 billion cubic feet (100 million cubic meters) in May of that year (MMES 1993a). Therefore no impacts to water supply from SNF operations are expected.

Operation of SNF management facilities would involve the discharge of almost all water withdrawn, as very little would be consumed. A new onsite sanitary wastewater treatment plant would be required at the SNF facility. If all water withdrawn were to be treated and released at a constant rate over the course of a year, the increased flow from SNF operations would be approximately 0.13 gallon (0.5 liter) per second. Flow in Grassy Creek at its confluence with the Clinch River has been estimated at 20 gallons (80 liters) per second. Water discharge points and other appropriate mitigation measures would be selected in accordance with state and Federal requirements so as not to impact surface water quantity and flow in streams receiving discharges.

5.8.2 Surface Water Quality

During construction of SNF management facilities, 90 acres (36 hectares) would be disturbed, all in previously undisturbed areas. This would create the potential for increased sediment runoff into wetlands, adjacent to the site and along the downstream reaches of Grassy Creek as well as into Grassy Creek and its tributaries, which drain to the Clinch River. However, sediment runoff from construction activities would be controlled and minimized by implementing soil erosion control measures.

Under the Centralization Alternative, SNF management facilities would require a sanitary sewer system comprising a sewage treatment facility equipped with a sewage treatment and ejection pump system with a programmable controller and software. A pressurized sanitary sewer line would be provided that would run to a permitted stream discharge point (Johnson, V. 1994). This would accommodate the estimated 9,863 gallons (37,335 liters) per day of sanitary wastewater generated by SNF facilities and personnel, and would result in no appreciable impact to surface water quality. This system would be operated in accordance with State of Tennessee permitting requirements.

The proposed SNF management facilities are designed to have no liquid release of wastewater with hazardous chemical or radiological characteristics related to SNF management operations. These facilities would be constructed using state-of-the-art technologies, including secondary containment, and leak detection and water balance monitoring equipment. Therefore no environmental consequences related to surface water resources are anticipated from the normal operation of SNF management facilities.

A very low probability release scenario was evaluated to identify the potential environmental consequences of a liquid release to the environment under normal operating conditions. The release scenario was evaluated for information purposes only, as no normal operating releases are planned for the proposed facilities. The scenario evaluated consisted of a maximum potential liquid release to the environment under normal operating conditions such as an undetected secondary containment failure or piping leak. The scenario was developed using conservative estimates of the sensitivity of actual leak detection systems and operational source term data from similarly functioning facilities at the Idaho National Engineering Laboratory

(INEL). The estimates for the hypothetical release included a point release of 5 gallons (19 liters) per day to the environment over the course of 1 month. The release volume and durations are considerably greater than existing leak detection system sensitivities, surveillance activities, and radiological surveys. Source terms were derived at the 95 percent confidence level from 8 years of operational data at the INEL Fluorinel and Storage Facility at the Idaho Chemical Processing Plant.

This release was assumed to occur at 40 feet (12 meters) below the land surface. This would be at either the depth of the vadose zone or the groundwater zone in most cases where SNF management facilities would be sited on the ORR. Any release to the vadose zone would migrate downward to the groundwater zone as described in Section 4.8.2. The upper layers of the groundwater zone in the ORR aquitards (where SNF management facilities would be sited) flow laterally to discharge points in nearby streams.

Most radiological constituents would be below drinking water standards at the point of release. Those radiological constituents above drinking water standards would be diluted in movements through the vadose zone, groundwater zone, and immediately upon entry into the receiving surface water body. Migration of contaminants through the vadose and groundwater zones would also be greatly reduced by sorption.

The short-term scenario evaluated would result in a long-term release of dilute contaminants to local streams and the Clinch River. Any release from the SNF management facilities would discharge to Grassy Creek through the subsurface. Although there are no continuous records of stream discharge for Grassy Creek, the average discharge of Grassy Creek to the Clinch River has been estimated at 20 gallons (80 liters) per second (Bailey and Lee 1991). The worst-case undetected release from the SNF facilities (5 gallons [19 liters] per day) would constitute less than 0.0003 percent of the estimated daily creek discharge to the Clinch River. Therefore, any hazardous constituents would be well below established standards at the confluence of Grassy Creek and the river. Even if a release were to occur during a period of low flow in Grassy Creek, the percentage would still be very small. Additionally, the 1992 minimum monthly release (in May) of 3.5 billion cubic feet (100 million cubic meters) at the Melton Hill Dam on the Clinch River averages to approximately 10,000 gallons (40,000 liters) per second (MMES 1994a). Therefore, no significant contaminant concentrations would be expected at the confluence of Grassy Creek and the Clinch River, or in the river itself.

5.8.3 Groundwater Quantity

No groundwater would be used for SNF management activities given the plentiful surface water supplies at the ORR. Therefore no impacts to groundwater quantity are expected.

5.8.4 Groundwater Quality

As previously mentioned in Section 5.8.2, the proposed SNF management facilities would be designed to have no liquid release to the environment of wastewater with hazardous chemical or radiological characteristics. However, for the purpose of this analysis, a conservative release scenario was analyzed.

As discussed in Section 4.8, virtually all mobile groundwater in the ORR aquitards is discharged to local streams through the upper layers of the groundwater zone. The deeper intervals of groundwater have extremely high residence times. Therefore, even the conservative scenario of a release to groundwater would have negligible impacts to these resources, and no significant impacts to offsite groundwater.

5.9 Ecological Resources

The Centralization and Regionalization Alternatives could affect ecological resources primarily through the alteration or loss of habitat. Potential impacts to terrestrial and aquatic resources and threatened and endangered species are described below for both alternatives.

Radiation doses received by terrestrial biota from SNF activities would be expected to be similar to those received by man. Although guidelines have not been established for acceptance limits for radiation exposure to species other than man, it is generally agreed that the limits established for humans are also conservative for other species (NRC 1979). Evidence indicates that no other living organisms have been identified that are likely to be significantly more radiosensitive than man (Casarett 1968; National Academy of Sciences 1972). Thus, so long as exposure limits protective of man are not exceeded, no significant radiological impact on populations of biota would be expected as a result of SNF activities at the West Bear Creek Site.

5.9.1 Centralization Alternative

Under this alternative, construction of the proposed SNF management facility would result in the disturbance of approximately 90 acres (0.36 square kilometers), or less than 1 percent of the ORR. It is assumed that the area to be disturbed includes construction laydown areas, grading, and new buildings, and that the access road or other rights-of-ways have not been included in total area to be disturbed. Vegetation within the area proposed for the SNF management facility would be destroyed during land clearing activities but may be mitigated by revegetating with native species where possible. Vegetation cover in this area is predominantly oak-hickory forest or pine and pine-hardwood forest. Both forest types are common on the ORR and within the region.

Construction of the proposed SNF management facility would have some adverse effects on animal populations. Less mobile animals, such as amphibians, reptiles, and small mammals, within the project area would be destroyed during land-clearing activities. Larger mammals and birds in construction and adjacent areas would be disturbed by construction activities and would move to nearby suitable habitat. The long-term survival of these animals would depend on whether the area to which they moved was at or below its carrying capacity. Areas that would be revegetated upon completion of construction would be of minimal value to most wildlife but may be repopulated by more tolerant species.

The Migratory Bird Treaty Act is primarily concerned with the destruction of migratory birds, as well as their eggs and nests. It may be necessary to survey construction sites for the nests of migratory birds prior to construction and/or avoid clearing operations during the breeding season.

Activities associated with operation, such as noise, increased human presence and traffic, and night lighting could affect wildlife living immediately adjacent to the site. While these disturbances may cause some sensitive species to move from the area, most animals should be able to adjust.

Construction of the proposed SNF management facility would likely displace the forested wetlands adjacent to tributaries of Grassy Creek flowing through the proposed site. This unavoidable displacement of wetlands would be accomplished in accordance with the U.S. Army Corps of Engineers and Tennessee Water Quality Control Administration requirements. The potential also exists to disturb wetlands further down stream through erosion and sedimentation. Such impacts would be controlled through implementation of a soil erosion and sediment control plan. Construction-related discharges to Grassy Creek would be relatively low and have negligible impacts to wetlands associated with the creek. No impacts to wetlands are anticipated during facility operations.

Construction of the proposed SNF management facility would require the rechanneling of tributaries to Grassy Creek that cross the proposed site and, thus, the loss of this aquatic habitat.
In addition, soil erosion due to construction could cause water quality changes (primarily sediment loading) to Grassy Creek and its tributaries. These impacts could be minimized by implementation of soil erosion and sediment control measures. No operational impacts to aquatic resources are anticipated. It is assumed that the proposed project will have a water retention pond and a sewage lagoon area within the security fence that may provide minimal habitat for amphibians in the area.

No federally listed species are expected to be affected by construction and operation of the SNF management facility. Site surveys will be required to verify the presence of state-listed or other special status species. Land clearing activities may destroy protected plant species, such as purple fringeless orchid and pink lady's-slippers, that may occur within the site. State-listed species including the Cooper's, sharp-shinned, and red-shouldered hawks, the barn owl, and the black vulture, which potentially occur in the area, could be impacted by project activities. Approximately 90 acres (36 hectares) of potential nesting and foraging habitat would be lost as a result of construction activities. Because this type of habitat is abundant in the area, the loss is not expected to affect the viability of populations of these species. However, appropriate steps would be taken to prevent nest disturbance. The DOE would consult with the Tennessee Department of Environment and Conservation as appropriate to avoid or mitigate imminent impacts to state-listed species.

5.9.2 Regionalization Alternative

Impacts under this alternative are expected to be generally the same as under the Centralization Alternative. The major difference between the two is the total area to be disturbed. The Regionalization Alternative is expected to have fewer buildings required and, therefore, fewer acres to be disturbed.

5.10 Noise

As discussed in Section 4.10, noises generated on the ORR do not propagate offsite at levels that impact the general population. Thus, ORR noise impacts for both the Centralization and Regionalization Alternatives are those resulting from the transportation of personnel and materials to and from the site that affect the nearby communities, and those resulting from onsite sources that may affect some wildlife near these sources. The effect of noise on wildlife near SNF management facilities under the Centralization or Regionalization Alternatives would be addressed in a project-specific environmental assessments.

The transportation noises are a function of the size of the work force (e.g., an increase in the size of the work force would result in increased employee traffic and corresponding increases in deliveries by truck and rail, and a decreased work force would result in decreased employee traffic and corresponding decreases in deliveries). This analysis of traffic noise took into account noise from the major roadways that provide access to the ORR. Vehicles used to transport employees and personnel on roadways would be the principal sources of community noise impacts near the ORR from the Centralization and Regionalization Alternatives.

This analysis used the day-night average sound level to assess community noise as suggested by the U.S. Environmental Protection Agency (EPA 1974, 1982) and the Federal Interagency Committee on Noise (FICON 1992). The change in day-night average sound level from the baseline noise level for each alternative was estimated based on the projected change in employment and traffic levels from the baseline levels. The baseline levels are those for 1995. The combination of construction and operation employment was considered. A change in noise level below 3 decibels would not be expected to result in a change in community reaction (FICON 1992).

Under the Centralization Alternative the projected ORR work force might increase by about 9 percent in the years 2000 to 2002, during the peak construction period, and might decrease thereafter (Section 5.3). There would be a corresponding increase in private vehicle and truck trips to the site. The day-night average sound level at 15 meters (50 feet) from the roads that provide access to the ORR would be expected to increase by less than 1 decibel. No change is expected in the community reaction to noise along these routes. No mitigation efforts are necessary.

Under the Regionalization Alternative the traffic noise impacts would be the same as for the Centralization Alternative.

5.11 Traffic and Transportation

5.11.1 Centralization Alternative

The proposed SNF management activities would involve a small increase in the number of employees commuting to the ORR and the transportation of SNF and hazardous chemicals onsite. This section summarizes the potential transportation impacts due to the proposed SNF facilities on the ORR.

5.11.1.1 Level of Service. Levels of service were calculated for construction and

operation of the SNF facility at the ORR. The maximum reasonably foreseeable scenario for operations occurs when the projected combined employees and population are at the highest level. This occurs in 2001, when there are 4,184 employees and a projected population in the Region of Influence of 528,800. The Region of Influence includes Anderson, Blount, Knox, Loudon, and Roane counties. This is the region from which employees can be expected to commute. The employees and population associated with the proposed action generate direct trips in the Region of Influence. These trips to the site are distributed to the Region of Influence road network according to percentages based on a traffic flow to the site from where employees historically have lived. Increase in baseline population and indirect site-related employees will generate indirect traffic trips in the Region of Influence. These trips are distributed based on the current average daily traffic per present population in the region of influence for a given segment. Direct and indirect average daily traffic is added and a new level of service is determined. Construction and operation employees contribute little to the future traffic because they represent such a small percentage of the Region of Influence population growth.

The following segment has a poorer level of service due to site-related impacts over the future baseline. Tennessee State Route 61 between Interstate 75 at Norris and 25W at Clinton will worsen to a level of service of E while Tennessee State Route 62 between Interstate 75 at Knoxville and US 441/TN 33 at Knoxville will worsen to a level of service of F. There are no other site-related impacts on any other segment.

Road reconstruction, widening, modification of interchanges, and new interchange construction projects are planned for segments of Bear Creek Valley Road, Scarboro Road, and Tennessee State Routes 58, 62, and 95 (Johnson, C. 1994; MMES 1991b).

Possible mitigation of impacts on local and regional roads having level of service of F could include adding lanes or employing traffic demand management.

The generic facility design would require rail access for Naval fuel delivery. This would create impacts that would be evaluated in detail if the site were selected for the SNF facility.

5.11.1.2 Transportation of Hazardous Chemicals. The hazardous chemicals required

and hazardous waste generated by the proposed SNF facility operation are assumed to be transported by truck. The onsite transportation impacts for these hazardous chemicals and wastes shipments are calculated based on the assumptions that (a) they do not have any incident free impacts, (b) the material would not leak during transport, (c) only risk is due to traffic fatalities, and (d) the material spill of entire contents is bound by the risk evaluated for the Expended Core Facility considered under facility accidents.

The total distance for onsite shipment of these hazardous chemicals is assumed to be the maximum site boundary distance from the proposed SNF facility to the nearest highway. Based on the unit risk factor (Cashwell et al. 1986) and occupational and nonoccupational fatalities considering a rural setting, the onsite transportation risks are calculated, assuming 10 annual shipments.

The maximum one-way distance from the site to the ORR gate by which trucks would deliver hazardous waste is 16 kilometers (10 miles). Based on 1.5 x 10-8 accident occupational fatalities per kilometer per shipment, 1.92 x 10-4 accident occupational fatalities are estimated over a 40-year period. Based on 5.3 x 10-8 accident non-occupational fatalities per kilometer per shipment, 6.8 x 10-4 accident non-occupational fatalities are estimated for a 40-year period.

5.11.1.3 Transportation of Radioactive SNF. The definition of offsite transportation

includes transportation of radioactive material from the shipping facility to the storage facility at the receiving site; therefore this local transportation does not separately address the onsite transportation impacts due to radioactive materials shipment except for handling at the storage facility. Based on current inventories and expected future generation, DOE estimates approximately 480 spent nuclear shipments over 40 years (1995-2035) from the High Flux Isotope Reactor. The distance between the High Flux Isotope Reactor and the proposed SNF management facility at ORR is about 6 miles (9.75 km). Incident-free onsite radiological transportation impacts from the estimated 480 shipments were calculated for transportation crew members (occupational) and general population. Occupational dose of 0.34 person-rem over 40 years was calculated based on a unit risk factor of 7.16 x 10-5 person-rem per kilometer (Appendix I). This dose results in 1.36 x 10-4 fatal cancers. The general population dose of 8.56 x 10-3 person-rem over 40 years was calculated based on a unit risk factor of 1.83 x 10-6 person-rem per kilometer (Appendix I). This dose results in 4.28 x 10-6 fatal cancers.

5.11.2 Regionalization Alternative

The impacts due to the Regionalization Alternative would be less than those described for the Centralization Alternative.

5.12 Occupational and Public Health and Safety

5.12.1 Centralization Alternative

This section evaluates the impacts to human health resulting from both contaminated emissions and direct exposures associated with the proposed SNF management facility under the Centralization Alternative. Based on current inventories and expected future generation, DOE estimates approximately 480 spent nuclear shipments over 40 years (1995 - 2035) from the High Flux Isotope Reactor. The distance between the High Flux Isotope Reactor and the proposed SNF management facility at ORR is about 6 miles (9.75 km). Incident-free onsite radiological transportation impacts from the estimated 480 shipments were calculated for transportation crew members (occupational) and general population. Occupational dose of 0.34 person-rem over 40 years was calculated based on a unit risk factor of 7.16 x 10-5 person-rem per kilometer (Appendix I). This dose results in 1.36 x 10-4 fatal cancers. The general population dose of 8.56 x 10-3 person-rem over 40 years was calculated based on a unit risk factor of 1.83 x 10-6 person-rem per kilometer (Appendix I). This dose results in 4.28 x 10-6 fatal cancers.

5.12.1.1 Radiological Dose and Cancer Impacts. Computation and modeling (see

Table 5.7-1) have shown that the dose rate (due to atmospheric effluents only) to the maximally exposed individual, conservatively taken to be at the site boundary of the ORR (without the presence of the interim storage facility), is 3.3 millirem per year of site operation with an **associated risk of fatal cancer of 1.7 x 10-6 to this maximally exposed individual.** It has also been established (see Section 4.12.4) that liquid effluents may present an additional plausible dose rate of 15.2 millirem per year of site operation (MMES 1993a) to a potential maximally exposed individual at the site boundary (due to both water consumption [0.2 millirem] and exposure from liquid material [15 millirem]), yielding a corresponding risk of 7.6 x 10-6 per year of operation. Subsequently, an additional 6.2 millirem per year to the postulated maximally exposed individual at the site boundary has been tabulated due to the presence of interim storage facility gaseous effluents (no radioactive liquid effluents are expected from the interim storage facility). Thus, if the spent fuel were brought to the ORR, it could result in a total cumulative dose rate (ORR + interim storage facility) to the maximally exposed individual at the site boundary of 24.7 millirem per year of site operation (see Table 5.12-1), with an associated total risk from ORR operations of 1.2 x 10-5 for fatal cancer; the resulting increase in risk to this individual from ORR operations with SNF management included is 34 percent. The total dose (24.7 millirem) to the maximally exposed individual is well within all applicable DOE limits (i.e., 4 millirem per year from the drinking water pathway, 10 millirem per year from the airborne release pathways, and 100 millirem per year total for all pathways). Table 5.12-1 shows the relationship among the various sources of radiation doses to the maximally exposed individual. The risks are presented there for both 1 and 40 years of exposure. The latter values are approximate and correspond to the operating lifetime of the SNF facility.

The annual population dose (80-kilometer [50-mile] radius) from total site operations (without the interim storage facility) is 54 person-rem, resulting in an increase of fatal cancer of 0.027. The increase in annual population dose from SNF operations is 5 person-rem, resulting in an increase of 2.5 x 10-3 for fatal cancer.

Over 40 years the increase in fatal cancers from SNF operations is 0.10. The increase of 9 percent in fatal cancers to the population from site operations with SNF results in an increase from 0.019 to 0.021 percent in the comparison of the dose received from ORR to that received from background. Table 5.12-1 also includes a summary of these population health impacts.

Table 5.12-1. Critical Interim Storage Facility impacts on radiation dose and cancer risks at ORR.

	Dose rate to the maximally exposed individual (mrem per yr)	Associated fatal cancer risk (yr of operation)a	Associated facility lifetime fatal cancer risk (40 years)a	Population dose from total site operations (person-rem per yr)	Associated total cancer increase (person per yr of operation)	Associated facility lifetime fatal cancer increase (person per 40 years)
Natural background	295	1.5 x 10-4	5.9 x 10-3	279,000	140	5,580
Public						
Baseline site operations	18.5	9.2 x 10-6	3.7 x 10-4	54	0.027	1.1
SNF operations	6.2	3.1 x 10-6	1.2 x 10-4	5.2	2.5 x 10-3	0.10
Baseline & SNF	24.7	1.2 x 10-5	4.9 x 10-4	59	0.030	1.2
Percent increase SNF over baseline	34	34	34	9	9	9
Workers						
Baseline site operations	2.8b	1.1 x 10-6	4.5 x 10-5	48	0.019	0.76
SNF operations	40b	1.6 x 10-5	6.4 x 10-4	32	0.013	0.40a

a. Facility lifetime fatal cancer risk accounts for time-varying number of workers.

b. Dose rate to an average worker.

It has been assumed that the additional doses to SNF workers (due to interim storage facility operations) will be similar in nature to those for major DOE facility Waste Processing/Management personnel. Hence, by examining the dose data from 1989, 1990, and 1991 for Richland, INEL, and Savannah River Site and assuming that the nuclear activity of the SNF would remain fairly constant until it is dealt with at the interim storage facility, it may be asserted that a maximally exposed interim storage facility worker could plausibly receive an additional (above background) annual dose of 3 rem from normal operations; this is equivalent to a risk of 1.2 x 10-3 for fatal cancer per year of operation. However, the average calculated dose (incurred in 1989, 1990, and 1991) to SNF workers was approximately 40 millirem per year; this is equivalent to a risk of 1.6 x 10-5 for fatal cancer per year of operation, and to an approximate risk of 6.4 x 10-4 to a worker who is present during the entire 40-year facility lifetime.

An excess of 0.013 fatal cancer among all SNF facility workers is projected from peak annual operations; exposures to radiation over the lifetime of SNF operations could result in an excess of 0.40 fatal cancer. The maximum health effects due to radiological doses to a noninvolved worker, i.e., an ORR worker at a faciity other than SNF, would be on the order of 1 percent of the occupational exposure to an SNF worker based on analyses for the SRS and INEL sites. Table 5.12-1 includes a summary of the doses and fatal cancer risks to SNF workers.

5.12.1.2 Chemical Exposure Health Impacts. The calculated atmospheric maximum

concentrations of hazardous chemicals (at the site boundary) for the proposed action are presented in Table 5.7-5 in Section 5.7. The maximum concentrations at the site boundary reflect an exposure to a maximally exposed individual, whereas the maximum onsite concentrations reflect an exposure to a worker. Of the potential hazardous chemicals identified for the proposed action, cadmium, nickel and chromium VI (chrome) are carcinogens for which a total cancer risk is calculated. The remaining seven chemicals are noncarcinogens for which a hazard index is calculated. A hazard index value of greater than 1 serves as an indicator for potential adverse health effects.

The offsite concentrations in Table 5.7-5 represent values at public access roads within the reservation. However, a maximally exposed individual is assumed to be unable to take up residence on these roads, but instead takes up residence along the reservation fence line. The concentrations at the fence line are 62 percent of those listed as offsite. On the other hand, the concentrations at the roads, being the highest listed within the fence line, are used here to represent maximum concentrations for ORR workers.

Based on the maximum hazardous chemical concentrations at the site boundary, the lifetime fatal cancer risk and hazard index to the maximally exposed member of the public are 2.5 x 10-12 and 1.2 x 10-2, respectively. Based on the maximum concentrations onsite, the lifetime fatal cancer risk and hazard index to a worker are 4.0 x 10-12 and 1.9 x 10-2, respectively. This indicates that there will be virtually no health impacts from nonradiological releases.

5.12.1.3 Labor and Construction Health Risks. There are expected to be 25,212 total

occupational/total labor worker-years for the 40-year duration of the interim storage facility. Hence, over the 40-year interim storage facility life span, it is estimated that 807 total injuries/illnesses and 0.81 fatality to DOE and contractor personnel would result. The expected 4,352 total construction worker-years for the 40-year duration of the interim storage facility results in 270 total injuries/illnesses and 0.48 fatality to DOE and contractor personnel.

5.12.2 Regionalization Alternative

Although the Regionalization Alternative is not explicitly analyzed, its impacts will be less than those from the Centralization Alternative.

5.13 Utilities and Energy

Direct changes in utility demand as a result of the Centralization and Regionalization Alternatives were compared against the current capacity and peak demand for each utility resource. Impacts to provision of a utility are considered to occur if the current demand, average annual demand, or peak demand for a utility is equal to or exceeds the current available capacity within the designated Region of Influence. For the purpose of analysis, the Region of Influence for each resource area is defined as the area served by the utility provider responsible for meeting the service demands of the ORR.

5.13.1 Centralization Alternative

5.13.1.1 Water Consumption. For the Centralization Alternative, approximately 0.43

liter per second (6.85 gallons per minute) of water is required to operate all the modules within the facility (Harr 1994). The K-25 plant, which would provide water to the site, has a capacity of 184 liters per second (2,917 gallons per minute) (Fritts 1994).

The proposed SNF management facilities would require approximately 0.2 percent of the K-25 plant's water capacity. The K-25 plant would operate at 53 percent of its capacity when the SNF facilities' water requirements are combined with the 1990 peak water usage of 97 liters per second (1,533 gallons per minute).

5.13.1.2 Electrical Consumption. The proposed SNF management facilities under the

Centralization Alternative would require approximately 23,000 megawatt hours of electricity per year or approximately 2.63 megavolt-amperes average demand (Harr 1994). This represents 0.3 percent of ORR's 920 megavolt-ampere connected capacity. Thirty-one percent of the connected capacity of ORR would be utilized when the peak electric requirement of 285 megavolt-amperes was combined with the electrical requirements of the Centralization Alternative.

5.13.1.3 Fuel Consumption. Energy requirements for the proposed SNF management

facilities under the Centralization Alternative were calculated assuming that electrical power purchased from a utility provider was the primary source of energy; however, fossil fuels may be used to power backup generators and during construction. The amount of fuel required for these operations would be small and should not substantially increase ORR fuel requirements.

5.13.1.4 Wastewater Disposal. Under the Centralization Alternative, approximately

0.43 liter per second (6.85 gallons per minute) of wastewater would be generated (Harr 1994). A new onsite sanitary sewage system and wastewater treatment plant might be required at the SNF facility. If a new system is not built, and sanitary sewage and wastewater are treated at K-25, this addition would represent approximately 2 percent of the K-25 sanitary sewer treatment system capacity of 26 liters per second (417 gallons per minute). Ninety-four percent of the wastewater capacity of the K-25 sanitary sewer treatment system would be utilized when the peak wastewater production of 24 liters per second (378 gallons per minute) was combined with the wastewater production of the SNF management facilities.

5.13.2 Regionalization Alternative

5.13.2.1 Water Consumption. The proposed SNF management facilities under the

Regionalization Alternative would require less water than the facilities under the Centralization Alternative; therefore, the impacts would be less.

5.13.2.2 Electrical Consumption. The proposed SNF management facilities under the

Regionalization Alternative would require less electricity than the facilities under the Centralization Alternative; therefore, the impacts would be less.

5.13.2.3 Fuel Consumption. Energy requirements for the proposed SNF management

facilities under the Regionalization Alternative were calculated assuming that electrical power purchased from a utility provider was the primary source of energy; however, fossil fuels may be used to power backup generators and during construction activities. The amount of fuel required for these operations would be small and should not substantially increase ORR fuel requirements.

5.13.2.4 Wastewater Disposal. The proposed SNF management facilities under the Regionalization Alternative would produce less wastewater than the Centralization Alternative; therefore, the impacts would be less.

5.14 Materials and Waste Management

This section discusses the potential environmental consequences of the Centralization and Regionalization Alternatives for the management of chemical raw materials and transuranic, low-level radioactive, and hazardous waste at the ORR. Nonhazardous (sanitary) wastes are discussed in Section 5.8. Section 4.14 describes the waste categories and outlines the ongoing waste management activities for the ORR. These waste management activities include onsite and offsite waste treatment, onsite and offsite waste disposal, and onsite waste storage. Section 4.14 also describes the chemical raw material management activities for the ORR.

5.14.1 Methodology

This analysis considers the impact of the Centralization and Regionalization Alternatives on current waste management activities at the ORR (baseline conditions). In addition to requiring land area for SNF management, both alternatives would generate transuranic, low-level radioactive, hazardous, and nonhazardous wastes. Neither alternative is projected to generate mixed wastes or high-level wastes. This analysis is based on a comparison of the projected amounts of waste generated by the Centralization and Regionalization Alternatives versus the current waste generation rates and storage capacity at the ORR.

5.14.2 Materials and Waste Management

SNF management activities would require the use of chemicals, and it is conservatively assumed that all chemical raw materials used within the proposed SNF management facility would become hazardous wastes. The proposed SNF management facility would contribute transuranic, solid low-level, and sanitary (sewage) wastes. Table 5.14-1 presents the estimated waste generations by waste classification for each of the two alternatives (Centralization and Regionalization) and by each of two storage options (wet storage, dry storage).

5.14.2.1 Centralization Alternative. Under the Centralization Alternative, all DOE SNF (including Naval and domestic and foreign research reactors) will be transferred to and managed at the ORR.

5.14.2.2 Wet Storage Option. The wet storage option would generate transuranic, low-level, hazardous, and sanitary wastes. The effect that the projected amounts of each of these wastes would have on the ORR waste management is discussed below.

5.14.2.2.1 Transuranic Waste-Over a period of 40 years of operation the projected amount of transuranic waste generated due to the recovery and purification of transuranic products would be 644 cubic meters (22,750 cubic feet). The current storage capacity at the ORR (ORNL) is 833.4 cubic meters (295,000 cubic feet). ORNL will continue to generate transuranic waste, and disposal is eventually planned for the Waste Isolation Pilot Plant unit. If the Waste Isolation Pilot Plant unit does not come on line, the ORR transuranic waste storage

Table 5.14-1. Ten-year cumulative estimated waste generation for SNF alternatives at the ORR (m3).

Alternative/ storage option	Time period			
	1995-2004	2005-2014	2015-2024	2025-2034
Centralization Alternative				

Wet storage option				
Transuranic waste	161	161	161	161
Low-level waste	1,950	1,950	1,950	1,950
Hazardous waste	74	74	74	74
Sanitary waste (sewage)	1.2 x 105	1.2 x 105	1.2 x 105	1.2 x 105
Dry storage option				
Low-level waste	76	76	76	76
Sanitary waste (sewage)	1.9 x 104	1.9 x 104	1.9 x 104	1.9 x 104
Regionalization Alternative				
Wet storage option				
Transuranic waste	<161	<161	<161	<161
Low-level waste	<1,950	<1,950	<1,950	<1,950
Hazardous waste	<74	<74	<74	<74
Sanitary waste (sewage)	<1.2 x 105	<1.2 x 105	<1.2 x 105	<1.2 x 105
Dry storage option				
Low-level waste	<76	<76	<76	<76
Sanitary waste (sewage)	<1.9 x 104	<1.9 x 104	<1.9 x 104	<1.9 x 104

a. Source: Harr (1994).

capacity may have to be expanded to accommodate transuranic waste generated at the SNF facility.

5.14.2.2.2 Low-Level Waste-The wet storage option would generate liquid low-level waste as a result of its interim storage in water. Over a period of 40 years of operation, an estimated 7,800 cubic meters (over 2 million gallons) of low-level liquid waste might be generated. The total ORR (Y-12, K-25, ORNL) storage capacity for liquid low-level wastes is about 98,300 cubic meters (about 26 million gallons) (see Tables 4.14-1, 4.14-3, and 4.14-5). Impacts would be small.

5.14.2.2.3 Hazardous Wastes-Installation of the proposed SNF management facility would require additional management of hazardous wastes, including the placement of satellite storage areas within the SNF complex and more frequent offsite shipments of hazardous wastes. It is estimated that the wet storage option will generate approximately 7.4 cubic meters (261 cubic feet) of waste annually. Currently ORR manages about 10,000 cubic meters (about 353,000 cubic feet) of hazardous waste annually (see Tables 4.14-1, 4.14-3, and 4.14-5); therefore, the impact of SNF generated hazardous waste on the management of hazardous waste at the ORR would be minimal.

5.14.2.2.4 Sanitary Waste-Sanitary wastes are covered in Section 5.8.

5.14.2.3 Dry Storage Option. The dry storage option would generate low-level waste and sanitary waste. The effects that the projected amounts of each of these wastes would have on the ORR waste management is discussed below.

5.14.2.3.1 Low-Level Waste-The low-level radioactive contaminated waste stream would result from wastes generated during decontamination operations. Over a period of 40 years of operation, an estimated 304 cubic meters (10,700 cubic feet) of low-level waste might be generated. As reported in Section 5.14.2.2.2 the total ORR storage capacity for liquid low-level waste is about 98,300 cubic meters (about 26 million gallons). Impacts from SNF operations on low-level waste management would be minimal.

5.14.2.3.2 Sanitary Waste-Sanitary wastes are covered in Section 5.

8.

5.14.2.2 Regionalization Alternative. Under the Regionalization Alternative, the ORR

would be the alternate site for the SRS. This alternative would generate less waste from the SNF complex than the Centralization Alternative since it is the alternative that stores less SNF. For either the wet storage or dry storage option, the waste generated would be less than those presented for the Centralization Alternative. Therefore, Table 5.14-1 presents the estimated waste generation for the SNF for the Regionalization Alternative as less than those generated for the Centralization Alternative. The impacts presented for each of the waste categories for its two options (wet storage, dry storage) for the Centralization Alternative apply to the Regionalization Alternative as well.

5.15 Facility Accidents

A potential exists for accidents at facilities associated with the handling, inspection, and storage of spent nuclear fuel at the ORR. Accidents can be categorized into events that are abnormal (for example, minor spills), events a facility was designed to withstand, and events a facility is not designed to withstand. These categories are termed abnormal, design basis, and beyond design basis accidents, respectively. Summarized here are consequences of possible facility accidents for a member of the public at the nearest site boundary and at the nearest road, for the collective population within 80 kilometers (50 miles), for workers, and for the environment. See Section 5.11 for a summary of the assessment of transportation accidents.

A review of the historical record of accidents at the ORR is summarized in the following section. Methods used to assess potential future events are summarized in Section 5.15.2. Evaluations of accident impacts by alternative are summarized in Sections 5.15.3 through 5.15.7. A summary comparison of accident impacts by alternative is given in Section 3.2. Additional supporting documentation for the accident impacts is given in a separate report (HNUS 1995).

This section examines the various activities that have been performed to assess the potential for accidents and their consequences for workers and the public for each alternative. A set of potential reasonably foreseeable accidents over the 40-year period are described which envelop all accidents. Secondary impacts of accidents pertaining to cultural resources, economics, land use, endangered species, water resources, and ecology are also addressed. This section also addresses emergency preparedness plans that have been established to mitigate the primary and secondary effects of accidents.

5.15.1 Historical SNF Accidents at ORR

The records of unusual events, including accidents, at the ORR have been reviewed to determine whether there have been any accidents with offsite impacts. The results indicate that there have been no accidents at the ORR associated with SNF that have had significant offsite consequences for the general public.

5.15.2 Methodology

5.15.2.1 Existing Facilities.

5.15.2.1.1 Assumptions and Approach-The potential accidents associated with

the existing SNF management facilities and operations were screened to determine which ones to include in the accident analysis for the No Action Alternative. Source terms were developed for each accident analysis. The GENII code (PNL 1988) was used to estimate accident consequences for the general public and for individuals onsite or at the site boundary based on both 50 percent and 95 percent meteorology. Accident consequences and risk are described in terms of dose, cancer fatalities, and total health detriments for workers, an individual at the site boundary, and the public residing as far as 80 kilometers (50 miles) from the proposed SNF management facility.

5.15.2.1.2 Accident Screening-The potential accidents associated with the existing

SNF management facilities and operations were screened to determine which ones to include in the accident analysis for the No Action Alternative. Initiating events were reviewed including natural phenomena (earthquakes, tornadoes, etc.), human initiated events (human error), equipment failures, fires, explosions, airplane crashes, and terrorism. One reference design basis fuel handling accident was selected for detailed analysis.

The dam in the High Flux Isotope Reactor fuel pool is removed and stored within the pool during refueling operations. The reference design basis fuel handling accident postulated that during refueling operations, the dam falls and damages all the 62 spent fuel cores, including the most recently discharged core, located in the pool. The fission products from all 62 spent fuel cores are released to the water in the pool (ORNL 1992b).

A beyond design basis tornado accident was considered that resulted in collapse of the High Flux Isotope Reactor bay roof and the roof's major structural member falls into the fuel pool and damages all the 62 spent fuel cores located in the pool. The fission products from all 62 spent fuel cores are released to the water in the pool (Flanagan 1994).

Additional beyond design basis accidents initiated by an airplane crash were postulated for the High Flux Isotope Reactor and Bulk Shielding Reactor but were screened out because the probability of an airplane crash into the fuel pool was estimated to be less than 1.0 x 10-7 per year.

The consequences of postulated operational and reference design basis accidents for the existing facilities are enveloped by the accident consequences presented in Subsection 5.15.4 for the Centralization Alternative.

5.15.2.2 New Facilities. In the absence of suitable design details for new SNF

management facilities during this stage of the SNF Management Program upon which to base an accident analysis, the approach makes use of accident scenarios and associated data that have been analyzed and documented for similar facilities. They include spent nuclear fuel facilities at INEL, Hanford, Savannah River Site, and Naval sites.

5.15.2.2.1 Assumptions and Approach-A number of postulated accidents for the

similar facilities have been selected to serve as a common basis for estimating accident consequences for workers and the public at the ORR site. Although the accident scenarios, source terms, and related assumptions are common for both sites, the estimated consequences are unique to the ORR site because of site differences in modeling parameters pertaining to distances to site boundaries and population centers, population distributions, and meteorology. The GENII code was used to estimate accident consequences for the general public and for individuals onsite or at the site boundary based on both 50 percent and 95 percent meteorology. Accident consequences and risk are described in terms of dose, cancer fatalities, and total health detriments for workers, an individual at the site boundary, a transient individual at the nearest public access, and the public residing as far as 80 kilometers (50 miles) from the proposed SNF facility. The estimated frequency of each selected accident is based on the reference source documentation.

The probability of an airplane crash into the new SNF management facility is considered small because there are no nearby airports with large aircraft activity. The probability is expected to be in the 1 x 10-6 to 1 x 10-8 per year range. For calculational purposes the probability of this accident is conservatively estimated at 1 x 10-6 per year. Potential accidents initiated by an airplane crash into the SNF management facilities and the estimated consequences have been analyzed.

The secondary impacts of accidental releases of radioactive and hazardous materials are also addressed in a qualitative manner. Secondary impacts pertain to effects of accidents on land use, endangered species, water resources, cultural resources, and ecology.

5.15.2.2.2 Accident Screening-The potential accidents associated with existing

SNF management facilities and operations were screened to determine which ones to include in the accident analysis for the ORR.
The source documentation for this purpose was primarily
Appendices A, B, C, and D of Volume 1 of this EIS. The source documentation describes potential accidents for existing and planned SNF management facilities that were selected by a screening process. Initiating events were reviewed including natural phenomena (earthquakes, tornadoes, etc.), human initiated events (human error), equipment failures, fires, explosions, airplane crashes, and terrorism. Accidents associated with the Expended Core Facility operations at the ORR, were analyzed separately and the results are documented in Appendix D of this EIS. For the ORR the maximum reasonably foreseeable criticality and nonradiological accidents are associated with the Expended Core Facility. The potential for a criticality exists while the fuel is in dry storage, during handling, and in the wet storage pool. Although the probability of
any criticality is very low, a hypothetical criticality of 1 x 1019 fissions was postulated in the
Expended Core Facility wet pool as a basis for estimating the maximum reasonably foreseeable consequences of a criticality.

The selected accidents include beyond reference design basis events to reflect the magnitude of accident consequences that envelop all other accidents that have a reasonable probability of occurrence. They also include other accidents with lower consequences and typically higher probabilities of occurrence to show a range of accident types and consequences. The accidents included in this set are reasonably foreseeable, meaning that there are one or more sequences of events that will lead to their occurrence and the sequence with the lowest probability of occurrence is greater than 1 x 10-7 per year. Accidents falling outside of this envelope, such as a meteorite impact, have been judged unreasonable because the probability of occurrence in less than 1 x 10-7 per year.

5.15.2.2.3 Accident Prevention and Mitigation - Under the Centralization and

Regionalization alternatives, the SNF management facilities at the ORR will be of new design and construction and incorporate the latest technology for safety.
The accidents postulated for
the SNF management facilities are based on operations and safety analyses that have been performed at similar facilities. One of the major design goals for the SNF management facilities is to achieve a reduced risk to facility personnel and to public health and safety relative to that
associated with similar functions at the existing SNF management facilities. Significant changes exist between design criteria and safety standards for the new SNF management facilities and those for the current facilities, thus reducing total risk. These changes include design to current
DOE structural and safety criteria and to planned throughput and storage capacity.

The new SNF management facilities would be designed to comply with current Federal, state, and local laws, DOE Orders, and industrial codes and standards. This would provide facilities that are highly resistant to the effects of severe natural phenomena, including earthquake, flood, tornado, high wind, as well as credible events as appropriate to the site, such
as fire and explosions, and man-made threats to its continuing structural integrity for containing
materials.

Emergency preparedness plans have also been prepared for existing facilities and will be revised for new facilities to lower the potential consequences of an accident to workers and the public. All workers receive evacuation training to ensure timely and orderly personnel movement away from high-risk areas. Plans and arrangements with local authorities are also in place to evacuate the general public that may be at risk of exposure to hazardous materials that are accidentally released.

5.15.3 No Action Alternative

There is a potential for the accidental release of radioactive substances during various stages of SNF handling operations and storage. The operations begin with discharge of SNF from the reactor during refueling operations. The discharged SNF is placed in the fuel pool for cooling and short term storage. After an adequate cooldown period, SNF is removed from the pool and transported offsite for long term storage. Accidents that may occur during these handling operations and storage may involve the release of radioactive material to air or water pathways. The cause of accidents may be due to internal initiators, such as operator error, equipment failure, and terrorism, or external initiators, such as an earthquake.

In the event that SNF can not be transported offsite for long term storage, reactor operations will cease when the fuel pool is full. Presently the SNF stored in the ORR fuel pools is sound and has not deteriorated. If the existing SNF were to remain in the ORR fuel pools for an extended period of time and deterioration of the aluminum fuel cladding occurred, there are no existing facilities at the ORR to characterize the SNF.

5.15.3.1 Radiological Impacts. The potential accidents associated with the existing SNF management facilities and operations were screened to determine which ones to include in the accident analysis for the No Action Alternative. One reference design basis accident and one beyond design basis accident were selected for detailed analysis. Although other accidents may occur, their estimated consequences are bounded by this beyond design basis accident or their probability of occurrence is less than 1.0 x 10-7per year. If these accidents were to occur, the dose and risk to the onsite worker and the general population are shown in Tables 5.15-1 and 5.15-2 for 95 percent and 50 percent meteorology respectively. Similarly, cancer fatalities are shown in Tables 5.15-3 and 5.15-4, and the health effects are shown in Tables 5.15-5 and 5.15-6.

5.15.3.1.1 Reference Design Basis Accident-The dam that separates the High Flux Isotope Reactor pool from the clean center pool during normal reactor operation is moved to a position between the east and center clean pools prior to defueling the reactor. The dam is lifted approximately 3 feet above the water over its slot between the reactor and center pools, then moved with the crane across the center clean pool, and then lowered into its slot between the east and center pools. During this movement, and when the dam is being moved back, the fuel in the center pool is subjected to the possibility of dropping the dam and mechanically

Table 5.15-1. Summary of No Action Alternative accident analysis dose and risk estimates for the Oak Ridge Site at 95 percent meteorology.

		95 percent meteorology							
		Dose				Risk			
Accident scenario	Frequency (per year)	MEIa (rem)	NPAIb	Workerd (rem)	Population (person-rem)	MEI (rem/yr)	NPAI (rem/yr)	Worker	Population (person-rem/yr)
Dropped dam	1.0 x 10-4 e	3.7 x 10-1	6.2 x 10-1	2.3 x 10-2	3.5 x 103 c	3.7 x 10-5	6.2 x 10-5	2.3 x 10-6	3.5 x 10-1
Beyond design basis tornado	1.9 x 10-7	4.9 x 100 d	7.5 x 101	2.6 x 101	4.5 x 104 d	9.3 x 10-7	1.4 x 10-5	4.9 x 10-6	8.6 x 10-3

a. Maximum exposed individual (MEI).

b. Nearest public access individual (NPAI) - Radiation exposure received from inhalation and external pathways.

c. Radiation exposure received from inhalation, external, and ingestion pathways.

d. Radiation exposure received from inhalation and external pathways.

e. The value is expected to be in the 1.0 x 10-4 to 1.0 x 10-6 range. For calculational purposes, the value is assumed to be 1.0 x 10-4.

Table 5.15-2. Summary of No Action Alternative accident analysis dose and risk estimates for the Oak Ridge Site at 50 percent meteorology.

		50 percent meteorology							
		Dose				Risk			
Accident scenario	Frequency (per year)	MEIa (rem)	NPAIb	Workerd (rem)	Population (person-rem)	MEI (rem/yr)	NPAI (rem/yr)	Worker	Population (person-rem/yr)
Dropped dam	1.0 x 10-4 e	8.6 x 10-2	1.9 x 10-1	5.7 x 10-3	1.2 x 103 c	8.6 x 10-6	1.9 x 10-5	5.7 x 10-7	1.2 x 10-1
Beyond design basis tornado	1.9 x 10-7	9.5 x 10-1	1.9 x 101	4.0 x 100	7.2 x 103 d	1.8 x 10-7	3.6 x 10-6	7.6 x 10-7	1.4 x 10-3

a. Maximum exposed individual (MEI).

b. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

c. Radiation exposure received from inhalation, external, and ingestion pathways.

d. Radiation exposure received from inhalation and external pathways.

e. The value is expected to be in the 1.0 x 10-4 to 1.0 x 10-6 range. For calculational purposes, the value is assumed to be 1.0 x 10-4.

Table 5.15-3. Summary of No Action Alternative accident analysis cancer fatality and risk estimates for the Oak Ridge Site at 95 percent meteorology.

		95 percent meteorology							
		Cancer fatalities				Cancer fatality risk (cancer fatalities/year)			
Accident scenario	Frequency (per year)	MEI[a]	NPAI[b]	Worker[d]	Population	MEI	NPAI	Worker	Population
Dropped dam	1.0 x 10-4 [e]	1.8 x 10-4	3.1 x 10-4	9.2 x 10-6	1.7 x 100 [c]	1.8 x 10-8	3.1 x 10-8	9.2 x 10-10	1.7 x 10-4
Beyond design basis tornado	1.9 x 10-7	2.5 x 10-3	7.5 x 10-2	2.0 x 10-2	2.3 x 101 [d]	4.8 x 10-10	1.4 x 10-8	3.8 x 10-9	4.4 x 10-6

a. Maximum exposed individual (MEI).

b. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

c. Radiation exposure received from inhalation, external, and ingestion pathways.

d. Radiation exposure received from inhalation and external pathways.

e. The value is expected to be in the 1.0 x 10-4 to 1.0 x 10-6 range. For calculational purposes, the value is assumed to be 1.0 x 10-4.

Table 5.15-4. Summary of No Action Alternative accident cancer fatality and risk estimates for the Oak Ridge Site at 50 percent meteorology.

		50 percent meteorology							
		Cancer fatalities				Cancer fatality risk (cancer fatalities/year)			
Accident scenario	Frequency (per year)	MEI[a]	NPAI[b]	Worker[d]	Population	MEI	NPAI	Worker	Population
Dropped dam	1.0 x 10-4 [e]	4.3 x 10-5	9.5 x 10-5	2.3 x 10-6	6.2 x 10-1 [c]	4.3 x 10-9	9.5 x 10-9	2.3 x 10-10	6.2 x 10-5
Beyond design basis tornado	1.9 x 10-7	4.8 x 10-4	9.5 x 10-3	1.6 x 10-3	3.6 x 100 [d]	9.1 x 10-11	1.8 x 10-9	3.0 x 10-10	6.8 x 10-7

a. Maximum exposed individual (MEI).

b. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

c. Radiation exposure received from inhalation, external, and ingestion pathways.

d. Radiation exposure received from inhalation and external pathways.

e. The value is expected to be in the 1.0 x 10-4 to 1.0 x 10-6 range. For calculational purposes, the value is assumed to be 1.0 x 10-4.

Table 5.15-5. Summary of No Action Alternative accident analysis health effects and risk estimates for the Oak Ridge Site at 95 percent meteorology.

		95 percent meteorology							
		Total health detriments[a]				Total health detriment risk (detriments/year)			
Accident scenario	Frequency (per year)	MEI[b]	NPAI[c]	Worker[e]	Population	MEI	NPAI	Worker	Population
Dropped dam	1.0 x 10-4 [f]	2.7 x 10-4	4.6 x 10-4	1.3 x 10-5	2.5 x 100 [d]	2.7 x 10-8	4.6 x 10-8	1.3 x 10-9	2.5 x 10-4
Beyond design	1.9 x 10-7	3.6 x 10-3	1.1 x 10-1	2.9 x 10-2	3.3 x 101 [e]	6.8 x 10-10	2.1 x 10-8	5.5 x 10-9	6.3 x 10-6

basis tornado

a. The estimated number of cancer fatalities, cancer nonfatalities, and genetic defects resulting from the radiation exposure.

b. Maximum exposed individual (MEI).

c. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

d. Radiation exposure received from inhalation, external, and ingestion pathways.

e. Radiation exposure received from inhalation and external pathways.

f. The value is expected to be in the 1.0 x 10-4 to 1.0 x 10-6 range. For calculational purposes, the value is assumed to be 1.0 x 10-4.

Table 5.15-6. Summary of No Action Alternative accident analysis health effects and risk estimates for the Oak Ridge Site at 50 percent meteorology.

		50 percent meteorology							
		Total health detriments[a]				Total health detriment risk (detriments/year)			
Accident scenario	Frequency (per year)	MEI[b]	NPAI[c]	Worker[e]	Population	MEI	NPAI	Worker	Population
Dropped dam	1.0 x 10-4 [f]	6.3 x 10-5[d]	1.4 x 10-4	3.2 x 10-6	9.0 x 10-1 [d]	6.3 x 10-9	1.4 x 10-8	3.2 x 10-10	9.0 x 10-5
Beyond design basis tornado	1.9 x 10-7	6.9 x 10-4	1.4 x 10-2	2.2 x 10-3	5.3 x 100 [e]	1.3 x 10-1	2.7 x 10-9	4.2 x 10-10	1.0 x 10-6

a. The estimated number of cancer fatalities, cancer nonfatalities, and genetic defects resulting from the radiation exposure.

b. Maximum exposed individual (MEI).

c. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

d. Radiation exposure received from inhalation, external, and ingestion pathways.

e. Radiation exposure received from inhalation and external pathways.

f. The value is expected to be in the 1.0 x 10-4 to 1.0 x 10-6 range. For calculational purposes, the value is assumed to be 1.0 x 10-4.

damaging the fuel. There is also a possibility that the dam could somehow be dropped as it is being lowered into (or raised from) its place between the clean pools and then fall in a way that would damage the fuel in either pool. The reference design basis fuel handling accident postulated that during refueling operations, the dam falls and damages all the 62 spent fuel cores, including the most recently discharged core, located in the pool. The fission products from all 62 spent fuel cores are assumed to be instantaneously released into the water in the pool. The analysis assumed that the pool area exhaust system was operational, it carried off all evaporated fission products, it filtered the stream, and it released the remaining fission products up the stack.

The source term released up the stack is shown in Table 5.15-7. The frequency of occurrence for this accident is in the range of 1.0 x 10-4 to 1.0 x 10-6 per year (ORNL 1992b).

5.15.3.1.2 Beyond Design Basis Accident-The beyond design basis accident postulated that a beyond design basis tornado with wind speeds of approximately 300 mph struck the High Flux Isotope Reactor reactor bay.

The reactor bay roof collapses and the major structural member in the roof falls into the fuel pool and damages all the 62 spent fuel cores, including the most recently discharged core, located in the pool. The fission products from all 62 spent fuel cores are assumed to be instantaneously released into the water in the pool. The analysis assumed that all evaporated fission products are released directly to the environment at ground level. The source term is similar to the reference design basis accident source term present in Table 5.15-7 except that no credit was taken for filtration of the iodine evaporated from the pool. The iodine released in the beyond design basis source term is 100 times greater than the iodine released in the reference design basis accident source term (Flanagan 1994).

The annual return frequency of a tornado with wind speeds of approximately 300 mph at ORR is 1.4 x 10-5. The conditional probability for collapse of the reactor bay roof during a 300 mph tornado is 0.46. The ratio of the spent fuel area to the reactor bay floor area (i.e., the probability that the falling structural member will fall into the spent fuel area of the fuel pool) is 0.03. The frequency of occurrence for this beyond design basis accident is 1.9 x 10-7 per year (Flanagan 1994).

Due to the dose consequences associated with the postulated accident, protective actions were assumed for the offsite population. The analysis took no credit for evacuation of the public from the affected area. However, credit was taken for removing contaminated food from the general public.

Table 5.15-7. Estimated radionuclide releases for the High Flux Isotope Reactor fuel pool dam drop accident at ORR.

Isotope	Release Duration 0-2 hr Curies	 0-30 day Curies
Hydrogen-3 (Tritium)	3.5 x 102	3.5 x 102
Krypton-83m	1.9 x 102	1.9 x 102
Krypton-85	1.0 x 104	1.0 x 104
Krypton-85m	3.6 x 103	3.6 x 103
Krypton-87	4.2 x 10-1	4.2 x 10-1
Krypton-88	1.1 x 103	1.1 x 103
Iodine-151	3.8 x 100	1.5 x 101
Iodine-132	5.0 x 100	5.1 x 100
Iodine-133	4.7 x 100	6.2 x 100
Iodine-134	2.2 x 10-7	2.2 x 10-7
Iodine-135	7.4 x 10-1	8.1 x 10-1
Xenon-131m	2.3 x 103	2.3 x 103
Xenon-133	8.7 x 105	8.7 x 105
Xenon-133m	2.5 x 104	2.5 x 104
Xenon-135	1.7 x 105	1.7 x 105
Xenon-135m	1.2 x 103	1.2 x 103

Source: ORNL 1992b

5.15.3.2 Nonradiological Hazards. The two bounding accidents involving nonradiological hazards postulated for the Centralization Alternative in subsection 5.15.4.2 are assumed to be bounding for the No Action Alternative. SNF operations under the No Action Alternative should not introduce any nonradiological hazards unique to the ORR SNF facilities.

5.15.4 Centralization Alternative

There is a potential for the accidental release of radioactive substances during various stages of SNF handling operations and storage. The operations at the new SNF management facilities begin with the receipt of an SNF shipment by truck or rail carrier, followed by the unloading of the shipping cask from the transport vehicle. If the SNF requires cooling, the cask is placed into an unloading pool where the SNF is withdrawn from the cask, moved to a temporary wet storage basin, and placed into a fuel rack. Some SNF that does not require cooling will be handled in a special cell where it will undergo canning and/or characterization. SNF that does not have to be cooled and does not require canning and/or characterization will be loaded into a dry storage canister within a transfer cask and transported to modular above-grade dry storage. Accidents that may occur during these handling operations and storage at the existing or new SNF management facilities may involve the release of radioactive material to air or water pathways. The cause of accidents may be due to internal initiators, such as operator error, terrorism, and equipment failure, or external initiators, such as an airplane crash into a facility.

5.15.4.1 Radiological Impacts. The accidents described below have been chosen to envelop the consequences of potential accidents for the proposed new SNF management facilities at the ORR. Although other accidents may occur, their estimated consequences are bounded by the accidents in the envelope or their probability of occurrence is less than 1 x 10-7 per year. If these accidents were to occur, the dose and risk would be as shown in Tables 5.15-8 and 5.15-9 for 95 percent and 50 percent meteorology respectively. These doses are in addition to the average natural background radiation exposure of 360 millirem per year. Similarly, cancer fatalities are shown in Tables 5.15-10 and 5.15-11, and the health effects are shown in Tables 5.15-12 and 5.15-13.

5.15.4.1.1 Fuel Assembly Breach-Physical damage and breach of a fuel assembly

could accidentally occur from dropping, objects falling on the assembly, or cutting into the fuel

Table 5.15-8. Summary of the Centralization Alternative accident analysis dose and risk estimates for the Oak Ridge Site at 95 percent meteorology.

		95 percent meteorology							
		Dose				Risk			
Accident scenario	Frequency (per year)	MEIa (rem)	NPAIb (rem)	Workerc (rem)	Populationd (person-rem)	MEI (rem/year)	NPAI (rem/year)	Worker (rem/year)	Population (person-rem/year)
Fuel assembly breach	1.6 x 10-1 e	1.2 x 10-2	3.8 x 10-3	1.5 x 10-3	2.1 x 101	1.9 x 10-3	6.1 x 10-4	2.4 x 10-4	3.4 x 100
Dropped fuel cask	1.0 x 10-4 f	7.8 x 100	1.2 x 101	4.7 x 100	1.9 x 104	7.8 x 10-4	1.2 x 10-3	4.7 x 10-4	1.9 x 100
Severe impact and fire	1.0 x 10-6 g	5.6 x 101	8.8 x 100	3.4 x 100	1.0 x 105	5.6 x 10-5	8.8 x 10-6	3.4 x 10-6	1.0 x 10-1
Wind-driven missile impact into dry storage	1.0 x 10-5	2.2 x 10-2	2.9 x 10-2	1.2 x 10-2	5.2 x 101	2.2 x 10-7	2.9 x 10-7	1.2 x 10-7	5.2 x 10-4
Airplane crash into dry storage	1.0 x 10-6 g	9.0 x 100	3.4 x 101	1.2 x 101	1.7 x 104	9.0 x 10-6	3.4 x 10-5	1.2 x 10-5	1.7 x 10-2
Airplane crash into dry cell facility	1.0 x 10-6 g	7.6 x 101	5.8 x 101	2.3 x 101	1.2 x 105	7.6 x 10-5	5.8 x 10-5	2.3 x 10-5	1.2 x 10-1
Airplane crash into water pool	1.0 x 10-6 g	1.4 x 10-1	5.9 x 10-2	2.3 x 10-2	5.6 x 103	1.4 x 10-7	5.9 x 10-8	2.3 x 10-8	5.6 x 10-3

a. Maximum exposed individual (MEI). Dose received from inhalation, external, and ingestion pathways.

b. Nearest public access individual (NPAI). Dose received from inhalation and external pathways.

c. Dose received from inhalation and external pathways.

d. Dose received from inhalation, external, and ingestion pathways.

e. The value is <1.6 x 10-1. For calculational purposes, the value is assumed to be 1.6 x 10-1.

f. The value is <1.0 x 10-4. For calculational purposes, the value is assumed to be 1.0 x 10-4.

g. The value is <1.0 x 10-6. For calculational purposes, the value is assumed to be 1.0 x 10-6.

Table 5.15-9. Summary of the Centralization Alternative accident analysis dose and risk estimates for the Oak Ridge Site at 50 percent meteorology.

		50 percent meteorology							
		Dose				Risk			
Accident scenario	Frequency (per year)	MEIa (rem)	NPAIb (rem)	Workerc (rem)	Populationd (person-rem)	MEI (rem/year)	NPAI (rem/year)	Worker (rem/year)	Population (person-rem/year)
Fuel assembly	1.6 x 10-1 e	1.2 x 10-3	6.7 x 10-4	3.2 x 10-4	2.5 x 100	1.9 x			

breach						10-4	1.1 x 10-4	5.1 x 10-5	4.0 x 10-1
Dropped fuel cask	1.0 x 10-4 f	7.5 x 10-1	2.2 x 100	1.0 x 100	2.7 x 103	7.5 x 10-5	2.2 x 10-4	1.0 x 10-4	2.7 x 10-1
Severe impact and fire	1.0 x 10-6 g	5.5 x 100	1.6 x 100	7.5 x 10-1	1.2 x 104	5.5 x 10-6	1.6 x 10-6	7.5 x 10-7	1.2 x 10-2
Wind-driven missile impact into dry storage	1.0 x 10-5	2.1 x 10-3	5.5 x 10-3	2.5 x 10-3	7.7 x 100	2.1 x 10-8	5.5 x 10-8	2.5 x 10-8	7.7 x 10-5
Airplane crash into dry storage	1.0 x 10-6 g	8.9 x 10-1	6.2 x 100	2.7 x 100	2.5 x 103	8.9 x 10-7	6.2 x 10-6	2.7 x 10-6	2.5 x 10-3
Airplane crash into dry cell facility	1.0 x 10-6 g	7.2 x 100	1.1 x 101	5.1 x 100	1.5 x 104	7.2 x 10-6	1.1 x 10-5	5.1 x 10-6	1.5 x 10-2
Airplane crash into water pool	1.0 x 10-6 g	1.3 x 10-2	1.1 x 10-2	5.0 x 10-3	5.2 x 102	1.3 x 10-8	1.1 x 10-8	5.0 x 10-9	5.2 x 10-4

a. Maximum exposed individual (MEI). Dose received from inhalation, external, and ingestion pathways.

b. Nearest public access individual (NPAI). Dose received from inhalation and external pathways.

c. Dose received from inhalation and external pathways.

d. Dose received from inhalation, external, and ingestion pathways.

e. The value is <1.6 x 10-1. For calculational purposes, the value is assumed to be 1.6 x 10-1.

f. The value is <1.0 x 10-4. For calculational purposes, the value is assumed to be 1.0 x 10-4.

g. The value is <1.0 x 10-6. For calculational purposes, the value is assumed to be 1.0 x 10-6.

Table 5.15-10. Summary of the Centralization Alternative accident analysis cancer fatality and risk estimates for the Oak Ridge Site at 95 percent meteorology.

		95 percent meteorology							
Accident scenario	Frequency (per year)	Cancer fatalities				Cancer fatality risk (cancer fatalities/year)			
		MEIa	NPAIb	Workerc	Populationd	MEI	NPAI	Worker	Population
Fuel assembly breach	1.6 x 10-1 e	6.0 x 10-6	1.9 x 10-6	6.0 x 10-7	2.1 x 10-2	9.6 x 10-7	3.0 x 10-7	9.6 x 10-8	3.4 x 10-3
Dropped fuel cask	1.0 x 10-4 f	3.9 x 10-3	6.0 x 10-3	1.9 x 10-3	1.9 x 101	3.9 x 10-7	6.0 x 10-7	1.9 x 10-7	1.9 x 10-3
Severe impact and fire	1.0 x 10-6 g	5.6 x 10-2	4.4 x 10-3	1.4 x 10-3	1.0 x 102	5.6 x 10-8	4.4 x 10-9	1.4 x 10-9	1.0 x 10-4
Wind-driven missile impact into dry storage	1.0 x 10-5	1.1 x 10-5	1.5 x 10-5	4.9 x 10-6	5.2 x 10-2	1.1 x 10-10	1.5 x 10-10	4.9 x 10-11	5.2 x 10-7
Airplane crash into dry storage	1.0 x 10-6 g	4.5 x 10-3	3.4 x 10-2	4.8 x 10-3	1.7 x 101	4.5 x 10-9	3.4 x 10-8	4.8 x 10-9	1.7 x 10-5
Airplane crash into dry cell facility	1.0 x 10-6 g	7.6 x 10-2	5.8 x 10-2	1.8 x 10-2	1.2 x 102	7.6 x 10-8	5.8 x 10-8	1.8 x 10-8	1.2 x 10-4
Airplane crash	1.0 x 10-6 g	6.9 x 10-5	3.0 x 10-5	9.2 x 10-6	5.6 x 100	6.9 x 10-11	3.0 x 10-11	9.2 x 10-12	5.6 x 10-6

into water pool

a. Maximum exposed individual (MEI). Radiation exposure received from inhalation, external, and ingestion pathways.

b. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

c. Radiation exposure received from inhalation and external pathways.

d. Radiation exposure received from inhalation, external, and ingestion pathways.

e. The value is <1.6 x 10-1. For calculational purposes, the value is assumed to be 1.6 x 10-1.

f. The value is <1.0 x 10-4. For calculational purposes, the value is assumed to be 1.0 x 10-4.

g. The value is <1.0 x 10-6. For calculational purposes, the value is assumed to be 1.0 x 10-6.

Table 5.15-11. Summary of the Centralization Alternative accident analysis cancer fatality and risk estimates for the Oak Ridge Site at 50 percent meteorology.

Accident scenario	Frequency (per year)	50 percent meteorology							
		Cancer fatalities				Cancer fatality risk (cancer fatalities/year)			
		MEI[a]	NPAI[b]	Worker[c]	Population[d]	MEI	NPAI	Worker	Population
Fuel assembly breach	1.6 x 10-1 [e]	6.0 x 10-7	3.4 x 10-7	1.3 x 10-7	1.3 x 10-3	9.6 x 10-8	5.4 x 10-8	2.1 x 10-8	2.1 x 10-4
Dropped fuel cask	1.0 x 10-4 [f]	3.7 x 10-4	1.1 x 10-3	4.0 x 10-4	2.7 x 100	3.7 x 10-8	1.1 x 10-7	4.0 x 10-8	2.7 x 10-4
Severe impact and fire	1.0 x 10-6 [g]	2.8 x 10-3	8.1 x 10-4	3.0 x 10-4	1.2 x 101	2.8 x 10-9	8.1 x 10-10	3.0 x 10-10	1.2 x 10-5
Wind-driven missile impact into dry storage	1.0 x 10-5	1.0 x 10-6	2.7 x 10-6	1.0 x 10-6	3.8 x 10-3	1.0 x 10-11	2.7 x 10-11	1.0 x 10-11	3.8 x 10-8
Airplane crash into dry storage	1.0 x 10-6 [g]	4.4 x 10-4	3.1 x 10-3	1.1 x 10-3	2.5 x 100	4.4 x 10-10	3.1 x 10-9	1.1 x 10-9	2.5 x 10-6
Airplane crash into dry cell facility	1.0 x 10-6 [g]	3.6 x 10-3	5.5 x 10-3	2.0 x 10-3	1.5 x 101	3.6 x 10-9	5.5 x 10-9	2.0 x 10-9	1.5 x 10-5
Airplane crash into water pool	1.0 x 10-6 [g]	6.4 x 10-6	5.5 x 10-6	2.0 x 10-6	5.5 x 10-1	6.4 x 10-12	5.5 x 10-12	2.0 x 10-12	5.5 x 10-7

a. Maximum exposed individual (MEI). Radiation exposure received from inhalation, external, and ingestion pathways.

b. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

c. Radiation exposure received from inhalation and external pathways.

d. Radiation exposure received from inhalation, external, and ingestion pathways.

e. The value is <1.6 x 10-1. For calculational purposes, the value is assumed to be 1.6 x 10-1.

f. The value is <1.0 x 10-4. For calculational purposes, the value is assumed to be 1.0 x 10-4.

g. The value is <1.0 x 10-6. For calculational purposes, the value is assumed to be 1.0 x 10-6.

Table 5.15-12. Summary of the Centralization Alternative accident analysis health effects and risk estimates for the Oak Ridge

Site at 95 percent meteorology.

		95 percent meteorology							
Accident Scenario	Frequency (per year)	Total health detrimentsa				Total health detriment risk (detriments/year)			
		MEIb	NPAIc	Workerd	Populatione	MEI	NPAI	Worker	Population
Fuel assembly breach	1.6 x 10-1 f	8.8 x 10-6	2.8 x 10-6	8.4 x 10-7	3.1 x 10-2	1.4 x 10-6	4.5 x 10-7	1.3 x 10-7	5.0 x 10-3
Dropped fuel cask	1.0 x 10-4 g	5.7 x 10-3	8.8 x 10-3	2.6 x 10-3	2.7 x 101	5.7 x 10-7	8.8 x 10-7	2.6 x 10-7	2.7 x 10-3
Severe impact and fire	1.0 x 10-6 h	8.2 x 10-2	6.4 x 10-3	1.9 x 10-3	1.5 x 102	8.2 x 10-8	6.4 x 10-9	1.9 x 10-9	1.5 x 10-4
Wind-driven missile impact into dry storage	1.0 x 10-5	1.6 x 10-5	2.1 x 10-5	6.8 x 10-6	7.5 x 10-2	1.6 x 10-10	2.1 x 10-10	6.8 x 10-11	7.5 x 10-7
Airplane crash into dry storage	1.0 x 10-6 h	6.6 x 10-3	5.0 x 10-2	6.7 x 10-3	2.4 x 101	6.6 x 10-9	5.0 x 10-8	6.7 x 10-9	2.4 x 10-5
Airplane crash into dry cell facility	1.0 x 10-6 h	1.1 x 10-1	8.5 x 10-2	2.6 x 10-2	1.8 x 102	1.1 x 10-7	8.5 x 10-8	2.6 x 10-8	1.8 x 10-4
Airplane crash into water pool	1.0 x 10-6 h	1.0 x 10-4	4.3 x 10-5	1.3 x 10-5	8.2 x 100	1.0 x 10-10	4.3 x 10-11	1.3 x 10-11	8.2 x 10-6

a. The estimated number of cancer fatalities, cancer nonfatalities, and genetic defects resulting from the radiation exposure.

b. Maximum exposed individual (MEI). Radiation exposure received from inhalation, external, and ingestion pathways.

c. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

d. Radiation exposure received from inhalation and external pathways.

e. Radiation exposure received from inhalation, external, and ingestion pathways.

f. The value is <1.6 x 10-1. For calculational purposes, the value is assumed to be 1.6 x 10-1.

g. The value is <1.0 x 10-4. For calculational purposes, the value is assumed to be 1.0 x 10-4.

h. The value is <1.0 x 10-6. For calculational purposes, the value is assumed to be 1.0 x 10-6.

Table 5.15-13. Summary of the Centralization Alternative accident analysis health effects and risk estimates for the Oak Ridge Site at 50 percent meteorology.

		50 percent meteorology							
Accident scenario	Frequency (per year)	Total health detrimentsa				Total health detriment risk (detriments/year)			
		MEIb	NPAIc	Workerd	Populatione	MEI	NPAI	Worker	Population
Fuel assembly breach	1.6 x 10-1 f	8.8 x 10-7	4.9 x 10-7	1.8 x 10-7	1.8 x 10-3	1.4 x 10-7	7.8 x 10-8	2.9 x 10-8	2.9 x 10-4
Dropped fuel cask	1.0 x 10-4 g	5.5 x 10-4	1.6 x 10-3	5.6 x 10-4	4.0 x 100	5.5 x 10-8	1.6 x 10-7	5.6 x 10-8	4.0 x 10-4
Severe impact and fire	1.0 x 10-6 h	4.0 x 10-3	1.2 x 10-3	4.2 x 10-4	1.8 x 101	4.0 x 10-9	1.2 x 10-9	4.2 x 10-10	1.8 x 10-5

Wind-driven missile impact into dry storage	1.0 x 10-5	1.5 x 10-6		4.0 x 10-6	1.4 x 10-6	5.6 x 10-3	1.5 x 10-11	4.0 x 10-11	1.4 x 10-11	5.6 x 10-8
Airplane crash into dry storage	1.0 x 10-6 h	6.5 x 10-4		4.5 x 10-3	1.5 x 10-3	3.6 x 100	6.5 x 10-10	4.5 x 10-9	1.5 x 10-9	3.6 x 10-6
Airplane crash into dry cell facility	1.0 x 10-6 h	5.2 x 10-3		8.0 x 10-3	2.9 x 10-3	2.2 x 101	5.2 x 10-9	8.0 x 10-9	2.9 x 10-9	2.2 x 10-5
Airplane crash into water pool	1.0 x 10-6 h	9.3 x 10-6		8.0 x 10-6	2.8 x 10-6	8.0 x 10-1	9.3 x 10-12	8.0 x 10-12	2.8 x 10-12	8.0 x 10-7

a. The estimated number of cancer fatalities, cancer nonfatalities, and genetic defects resulting from the radiation exposure.

b. Maximum exposed individual (MEI). Radiation exposure received from inhalation, external, and ingestion pathways.

c. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

d. Radiation exposure received from inhalation and external pathways.

e. Radiation exposure recieved from inhalation, external, and ingestion pathways.

f. The value is <1.6 x 10-1. For calculational purposes, the value is assumed to be 1.6 x 10-1.

g. The value is <1.0 x 10-4. For calculational purposes, the value is assumed to be 1.0 x 10-4.

h. The value is <1.0 x 10-6. For calculational purposes, the value is assumed to be 1.0 x 10-6.

part of an assembly. The fuel cutting accident that has been postulated to occur at Savannah River Site facilities is chosen as representative of the fuel assembly breach accident (E. I. du Pont de Nemours & Co. 1983). During normal operations at the Savannah River Site, the inert, non-uranium-containing extremities of some spent nuclear fuel elements are cutoff in the repackaging basin before the bundling of the elements. The accident occurs when the actual uranium fuel is inadvertently cut, causing a radioactive release. The source term for this accident is shown in Table 5.15-14. The estimated frequency of occurrence for this accident is 1.6 x 10-1 per year based on the Savannah River Site's operating experience with SNF. However, because of anticipated differences in operations and facilities at the ORR, the actual frequency is expected to be much less than 1.6 x 10-1 per year.

5.15.4.1.2 Dropped Fuel Cask-The dropped fuel cask accident that has been

postulated to occur at the Hanford Site (reference Volume 1, Appendix A) is chosen as representative of the dropped fuel cask/fuel handling accident for the new Centralization Alternative facility at the ORR.
This accident is initiated when a fuel cask is dropped and overturned in the fuel transfer area and broken fuel elements spill out of the cask, within the pool building but away from the pool. It is assumed that the shipping cask ruptures, exposing all of the broken fuel elements in three canisters--42 fuel elements, each containing 22.5 kilograms (50 pounds) of fuel. The source term for this accident is shown in Table 5.15-15. The probability of this accident is estimated to be less than 1 x 10-4 per year.

5.15.4.1.3 Severe Impact and Fire-The severe impact and fire accident that has

been postulated to occur at the Hanford Site (reference Volume 1, Appendix A) is chosen as representative of the severe impact and fire/onsite transportation accident for the new Centralization Alternative facility at the ORR.
This accident assumes an unspecified initiating event that subjects the fuel assemblies to a severe impact, breach of the transport cask, and a fire. During the accident, the fuel pins rupture on impact or upon heating in the fire, which burns for an hour before being extinguished. Volatiles, particulates, and noble gases are released to the atmosphere. The source term for a release of 540 curies is shown in Table 5.15-16. The estimated probability of occurrence for this accident, reflecting the fact that the facilities at

this site would be new, is less than 1 x 10-6 per year.

5.15.4.1.4 Wind-driven Missile Impact into Storage Casks-The wind-driven missile impact into storage casks accident that has been postulated to occur at the Naval Site (reference Volume 1, Appendix D) is chosen as representative of the wind-driven missile accident for the new Centralization Alternative facility at the ORR. This accident is initiated by natural phenomena: a major wind storm or tornado in excess of the facility design basis. In this scenario, a large object is propelled by the wind into a storage container, causing the container seal to be breached. No fuel damage would result from the impact because of the strength of the containers used. The source term is based on the spent nuclear fuel corrosion film. One percent of the original corrosion film on the fuel would be released from the cask into the atmosphere. The source term is shown in Table 5.15-17. The probability of this event is estimated to be less than 1 x 10-5 per year based on a design basis tornado probability of 1 x 10-3 per year and a missile impact with damage probability of less than 1 x 10-2.

Table 5.**15-14.** Estimated radionuclide releases for a fuel assembly breach accident at ORR.

Radionuclide	Release (Ci)
Iodine-131	7.1 x 10-2
Iodine-133	1.4 x 10-30
Krypton-85	1.8 x 102
Xenon-133m	1.1 x 10-8
Xenon-133	1.1 x 100

a. Source: E.I. du Pont de Nemours & Co. (1983).

Table 5.15-15. Estimated radionuclide releases for a dropped fuel cask accident at ORR.

Radionuclide	Release (Ci)	
	Onsite (2 hours)	Offsite (8 hours)
Plutonium-236	1.3 x 10-8	5.4 x 10-8
Plutonium-238	2.9 x 10-3	1.2 x 10-2
Plutonium-239	6.7 x 10-3	2.7 x 10-2
Plutonium-240	3.5 x 10-3	1.4 x 10-2
Plutonium-241	2.7 x 10-1	1.1 x 100
Plutonium-242	1.3 x 10-6	5.1 x 10-6
Americium-241	5.7 x 10-3	2.3 x 10-2
Curium-244	2.8 x 10-4	1.1 x 10-3
Europium-154	5.4 x 10-3	2.1 x 10-2
Cesium-134	7.9 x 10-3	3.2 x 10-2
Cesium-137	4.5 x 10-1	1.8 x 100
Cerium-144	1.7 x 10-3	6.8 x 10-3
Praseodymium-144	1.7 x 10-3	6.8 x 10-3
Praseodymium-144M	2.0 x 10-5	8.1 x 10-5
Promethium-147	1.2 x 10-1	4.9 x 10-1
Antimony-125	7.3 x 10-3	2.9 x 10-2
Tellurium-125M	1.8 x 10-3	7.3 x 10-3
Ruthenium-106	3.2 x 10-3	1.3 x 10-2
Strontium-90	3.5 x 10-1	1.4 x 100
Yttrium-90	3.5 x 10-1	1.4 x 100

a. Source: Appendix A, Table A-1.

Table 5.15-16. Estimated radionuclide releases for a severe impact and fire accident at ORR.

Radionuclide	Release (Ci)
Hydrogen-3 (Tritium)	4.6 x 101
Krypton-85	4.0 x 102
Strontium-90	2.7 x 10-2
Ruthenium-106	1.3 x 100
Cesium-134	1.7 x 101
Cesium-137	8.0 x 101
Plutonium-238	8.9 x 10-4
Plutonium-239	1.6 x 10-3
Plutonium-240	1.8 x 10-3
Plutonium-241	7.3 x 10-2
Americium-241	1.0 x 10-3

a. Source: Appendix A, Table A-14.

5.15.4.1.5 Airplane Crash Into Dry Storage-The airplane crash into dry storage

accident that has been postulated to occur at the Naval Site (reference Volume 1, Appendix D) is chosen as representative of the airplane crash into the dry storage area accident for the new Centralization Alternative facility at the ORR. This accident is externally initiated by an airplane crash into the SNF dry storage facility. The accident is postulated to cause damage to a single storage cask. Due to the severity of the impact, the cask seal is assumed to be breached, resulting in damage to the fuel and the release of corrosion products, located on the SNF exteriors, to the environment. The impact also causes a fire and a release of fission products. It is assumed that 1 percent of all of the fuel units stored inside the cask are damaged either by the impact or by the fire and that those fission products are available for release. Of the available fission products, 100 percent of the noble gases, 3 percent of the halogens, 1.1 percent of the cesium, and 0.1 percent of the remaining solids are released to the environment. Also, 10 percent of the original corrosion products from the fuel units are released from the cask to the atmosphere. The source term for this accident is shown in Table 5.15-18. The probability of this accident, based on analyses of other facilities at the site (Flanagan 1994), is small and assumed to be less than 1 x 10-6 per year.

5.15.4.1.6 Airplane Crash into Dry Cell Facility-The airplane crash into the dry

cell facility accident that has been postulated to occur at the Naval Site (reference Volume 1, Appendix D) is chosen as representative of the airplane crash into the canning and characterization cell accident for the new Centralization Alternative facility at the ORR. This accident is initiated by an airplane crash into the dry cell facility. The accident was postulated to cause significant damage to the building, resulting in the loss of containment and filtered exhaust systems. The fuel units inside the dry cell could also be damaged due to mechanical impacts and potential fire. The mechanical impact also could result in the release of corrosion products to the environment. For this accident scenario, 1 percent of the fuel units stored inside of the dry cell are assumed to be damaged by either the impact or resultant fire and those fission products would be available for release. Of the fission products available for release, 100 percent of the noble gases, 3 percent of the halogens, 1.1 percent of the cesium, and 0.1 percent of the remaining solids could be released to the environment. Ten percent of the available corrosion products could be released to the environment. The source term for this accident is shown in **Table 5.15-19.** The probability of this accident is estimated to be less than 1 x 10-6 per year.

Table 5.15-17. Estimated radionuclide releases for a wind-driven missile impact into a storage cask at ORR.

Radionuclide	Release (Ci)
Cobalt-60	9.6 x 10-2
Iron-55	1.8 x 10-1
Cobalt-58	3.5 x 10-2
Manganese-54	6.0 x 10-3
Iron-59	5.1 x 10-4

a. Source: See Section F.1.4.2.2.1, Appendix D to Volume 1.

Table 5.15-18. Estimated radionuclide releases for an airplane crash into dry storage facility at ORR.

Radionuclide	Release (Ci)
Cesium-134	2.6 x 101
Cesium-137	3.6 x 101
Plutonium-238	5.9 x 10-2
Barium-137m	3.1 x 100
Strontium-90	3.1 x 100
Cerium-144	7.2 x 100
Niobium-95	4.4 x 100
Yttrium-90	3.1 x 100
Ruthenium-106	6.1 x 10-1

a. Source: See Section F.1.4.2.2.2, Appendix D to Volume 1.

5.15.4.1.7 Airplane Crash into Water Pool-The airplane crash into the SNF water

pool accident that has been postulated to occur at the Naval Site (reference Volume 1,

Appendix D) is chosen as representative of the airplane crash into the SNF water pool accident for the new Centralization Alternative facility at the ORR. This externally initiated accident occurs when an airplane crashes into an SNF water pool and damages the fuel units stored there. Fission products and corrosion products are released from the fuel units into the water pool but the pool water is not released to the environment. The presence of the pool water results in a release only of gaseous fission products into the atmosphere. In this accident scenario, 1 percent of all the fuel units stored inside the pool were postulated to be damaged and those fission products are available for release. Of the available fission products, 100 percent of the noble gases and 25 percent of the halogens are released to the pool water. Due to the presence of pool water, there is a reduction of the halogen release by a factor of 10 prior to release into the atmosphere. The source term for this accident is shown in Table 5.15-20. The probability of this accident is estimated to be less than 1 x 10-6 per year.

5.15.4.1.8 Integration of Existing Facilities- Existing SNF management facilities

will be integrated into the Centralization, Regionalization, and Planning Basis Alternative SNF storage functions until the existing ORR operating reactors are shutdown. The accident consequences postulated for the No Action Alternative in subsection 5.15.3 can occur as long as the High Flux Isotope Reactor is operational. After the High Flux Isotope Reactor is no longer operational, the accident consequence will decrease as the spent reactor cores, stored in the pool, age. The reference design basis accident frequency of occurrence and risk will be reduced because refueling operations have ceased and requirements for movement of the dam are reduced. Since the beyond design accident is initiated by natural phenomenon (i.e., tornado), the beyond design basis accident frequency of occurrence will remain the same as long as spent High Flux Isotope Reactor cores remain in the spent fuel pool area.

Table 5.15-19. Estimated radionuclide releases for an airplane crash into dry cell facility at ORR.

Radionuclide	Release (Ci)
Cesium-134	4.5 x 101
Cesium-137	6.2 x 101
Plutonium-238	1.0 x 10-1
Barium-137m	5.4 x 100
Strontium-90	5.5 x 100
Cerium-144	1.3 x 101
Niobium-95	7.7 x 100
Yttrium-90	5.5 x 100
Ruthenium-106	1.1 x 100

a. Source: See Section F.1.4.2.3.3, Appendix D to Volume 1.

Table 5.15-20. Estimated radionuclide releases for an airplane crash into an SNF water pool at ORR.

Radionuclide	Release (Ci)
Iodine-129	7.6 x 10-4
Iodine-131	1.6 x 10-2
Hydrogen-3 (Tritium)	4.3 x 102

a. Source: See Section F.1.4.2.1.4, Appendix D to Volume 1.

5.15.4.2 Nonradiological Hazards. The two bounding accidents involving nonradiological

hazards are a chemical spill and fire and a diesel fuel fire. Both of these accidents are associated with the Expended Core Facility operations and the accident frequencies and impacts are addressed in Volume 1, Appendix D. The analyses of these accidents considered the impacts to workers on the site as well as to the offsite population. The impacts were measured in terms of potential health effects due to exposure to toxic chemicals released during these accidents. Since the Expended Core Facility at this site will be a new design and construction, it will incorporate all applicable standards and regulations and therefore limit the potential exposures to the workers and the public in the event of an accident.

5.15.4.3 Secondary Impacts. In the event of an accidental release of radioactive

substances, there is a potential for secondary impacts to cultural resources, endangered species, water resources, public and agricultural land use, the ecology in the vicinity of the accident, national defense, and local economics. Figure 5.15-1 illustrates the radiological impacts to the environment in the event of a severe accident at a new SNF management facility and the release of radioactive material with 50 percent meteorology. The accident chosen for this purpose is an airplane crash into the Centralization Alternative canning and characterization (dry) cell. Figure 5.15-1 shows several isodose lines ranging from 870 millirem per year down to 87 millirem per year. The solid line represents the site boundary, and it can be seen from the figure that some doses exceeding background would exist outside the site boundary.

Table 5.15-21 presents a summary of the postulated severe accident secondary impacts on the environment, economy, and national defense. The evaluation was performed using 50 percent meteorology.

5.15.5 Decentralization Alternative

The Decentralization Alternative is not applicable for the ORR.

Figure 5.15-1. Isodose lines for an airplane crash into dry cell accident with 50 percent meteorlogy at Oak Ridge Reservation.

Table 5.15-21. Secondary impacts of Centralization Alternative accidents at the ORR.

Environmental or social factor	Impact
Land use	Yes. Major portions of the ORR, including the ORNL and K-25 areas, will be contaminated. Offsite contamination will occur. Industrial, residential, forest, and agricultural areas will be contaminated.
Cultural resources	Yes. Archaeological sites, cemeteries, and historic sites will be contaminated.
Aesthetic and scenic resources	Possible impact. Scenic public viewing areas are within 2 miles of the ORR border.
Water resources	Yes. The Clinch River will be contaminated. It is used for industrial and public water supplies, navigation, fishing, boating, and swimming.
Ecological resources	Possible impact. Many endangered or threatened plants and animals are potentially on or near the ORR.
Treaty rights	No impact. There are no ORR areas subject to Native American Treaty rights.
National defense	Possible impact. With the 50 percent meteorology, the area of contamination does not envelop U.S. military facilities or the Y-12 area. However, with the 95 percent meteorology, the Y-12 area will be contaminated.
Economic impacts	Yes. Offsite contamination will occur. Industrial, residential, forrest, and agricultural areas will be contaminated. Major portions of the ORR will be contaminated. The accident consequences may require the evacuation and cleanup of onsite facilities, including but not limited to the ORNL and K-25 areas, and adjacent residential, industrial, forest, and agricultural areas. The Clinch River will be contaminated. The associated industrial and residential water supplies will be contaminated. The commercial and recreational fishing industries may be impacted.

5.15.6 1992/1993 Planning Basis Alternative

The facility accident consequences and risks for the ORR No Action Alternative envelop the facility accident consequences and risks for the 1992/1993 Planning Basis Alternative.

5.15.7 Regionalization Alternative

Under the Regionalization Alternative, new facilities will be constructed and operated for SNF. Details for the new facilities needed have not been defined, but it is reasonable to expect that they will be similar to but with less storage requirements than those needed for the Centralization Alternative. Due to smaller throughput and storage requirements, the potential for accidents (i.e., probability of occurrence) will be similar to but less than those described for the Centralization Alternative. The accident consequences will be similar for both alternatives. Consequently, it is reasonable to assume that the accident consequences and risks described for the Centralization Alternative envelop the Regionalization Alternative.

5.15.8 Emergency Preparedness and Plans

The DOE has issued a series of Orders specifying the requirements for emergency preparedness (DOE 5500.1A, DOE 5500.2A, DOE 5500.3, draft DOE 5500.3A, DOE 5500.4, and DOE 5500.9), and each DOE site has established an emergency management program. These programs are developed and maintained to ensure adequate response for most accident conditions and to provide the framework to readily extend response efforts for accidents not specifically considered. The emergency management program incorporates activities associated with planning, preparedness, and response.

Officials at each DOE site have specified the emergency preparedness requirements for the DOE facilities under their jurisdiction in a manner consistent with the relevant DOE Orders. All existing facilities have emergency plans and procedures that either implement the DOE and site requirements or are integrated with the site planning.

DOE-Oak Ridge Operations has overall responsibility at the plant and laboratory sites for emergency response. However, primary authority for event response has been delegated to Martin Marietta Energy Systems, Inc., DOE's operating contractor. Although their primary responsibility is onsite, they have agreed to provide offsite assistance if requested under the terms of existing mutual aid agreements or Martin Marietta policies. If a hazardous materials event occurs at a DOE-Oak Ridge Operations facility, the Governor of Tennessee is responsible for the State's response efforts. The Governor's Executive Order No. 4 establishes the Tennessee Emergency Management Agency as the agency given responsibility for coordinating state emergency services. If a hazardous materials accident at DOE-Oak Ridge Operations facilities is beyond the capability of the local government, and assistance is requested, the Tennessee Emergency Management Agency Director may direct that assistance from state agencies be provided to local governments. To accomplish this task and ensure prompt initiation of emergency response actions, the Director may cause the State Emergency Operations Center and Field Coordination Center as well as any local Emergency Operations Center to be activated.

5.16 Cumulative Impacts and Impacts From Connected

or Similar Actions

The ORR already contains several major DOE and non-DOE facilities, unrelated to SNF, that would continue to operate throughout the operating life of the proposed SNF management facilities. A number of offsite industrial and research facilities in surrounding areas would also continue to operate throughout this period. The activities associated with these existing facilities produce environmental consequences that have been included in the baseline environmental conditions (Chapter 4) against which Sections 5.1 through 5.15 have assessed the environmental consequences of the Centralization and Regionalization alternatives. This section uses the environmental baseline conditions presented in Chapter 4 to assess potential cumulative impacts from the proposed SNF management facilities, if constructed at the ORR, plus other reasonably foreseeable activities planned by government agencies or private concerns for areas on or near the ORR.

In addition to the proposed SNF management facilities, reasonably foreseeable activities considered in this cumulative impact assessment include the proposed Expended Core Facility, proposed hazardous waste remediation activities on the ORR, and activities proposed in the present Five-Year Plan for the ORR. Major programmatic initiatives planned for the ORR in the Five-Year Plan (MMES 1994a) consist of constructing the following: the proposed Advanced Neutron Source Facility; the proposed Uranium-Atomic Vapor Laser Isotope Separation Facility; facilities proposed for construction as a part of Complex-21; proposed low-level waste disposal facilities; the proposed Mixed Waste Treatment Facility; the proposed Environmental, Life, and Social Sciences Complex; the proposed Materials, Science, and Engineering Complex; and the proposed Solid Waste Storage Area-7. Several minor construction projects such as the refurbishment or expansion of existing facilities, widening of roadways, and installation of utilities are also included in the Five-Year Plan.

The ORR is part of the City of Oak Ridge, which also includes an urban area to the north of the ORR and several industrial areas in various locations around the perimeter of the ORR. Additional construction and expanded operational activities is anticipated in these industrial areas. For example, the Scientific Ecology Group, a private business in the Bear Creek Industrial Park on Bear Creek Road west of the ORR, is considering expanding its operations and is presently constructing a second radioactive waste incinerator. The City of Oak Ridge Comprehensive Plan encourages further development of several presently undeveloped lots in several industrial parks (City of Oak Ridge 1989). The Comprehensive Plan also anticipates additional residential and commercial development in the City. The City of Oak Ridge is presently proposing construction of a golf course and residential development on approximately 700 acres (2.8 square kilometers) east of the ORR.

The following cumulative impacts analysis considers in detail the potential incremental effects from the proposed SNF management facilities; the proposed Expended Core Facility; and the proposed Advanced Neutron Source facility. Adequate information is not available to consider in detail the other proposed Five-Year Plan activities or the proposed activities for areas in the City of Oak Ridge outside of the ORR. The potential incremental impacts from these activities are therefore assessed in a more qualitative manner.

5.16.1 Centralization Alternative

Separate analyses of potential cumulative impacts from the Centralization Alternative to each of the environmental resources addressed in Chapter 5 are provided below.

5.16.1.1 Land Use. Construction of the proposed SNF management facilities would

require the dedication of 90 acres (0.36 square kilometer) of undeveloped land on Bear Creek Road in the western part of the ORR. Construction of the proposed Expended Core Facility would require the dedication of an additional 30 acres (0.12 square kilometer) of undeveloped land on the ORR. Construction of the proposed Advanced Neutron Source facilities would require the dedication of an additional 75 to 115 acres (0.30 to 0.46 square kilometer) of land on the ORR (MMES 1992c). The cumulative land area dedicated to these three projects would total as much as 235 acres (0.95 square kilometer), which represents only about 1 percent of the roughly 20,600 acres (83 square kilometers) of undeveloped land remaining on the 34,667-acre (140 square kilometer) ORR. Additional unspecified areas of undeveloped land, generally parcels of under 100 acres (0.40 square kilometer), would have to be dedicated to some of the activities proposed in the Five-Year Plan. Many of these proposed activities do not require the dedication of undeveloped land. Additional undeveloped land on the ORR might have to be dedicated to the other planned activities, but their land requirements have not yet been quantified.

Although large areas of undeveloped land remain both on the ORR and in the City of Oak Ridge, much of this land is steep or otherwise has constraints that limit its future development potential. The City of Oak Ridge indicates in its Comprehensive Plan that it seeks to have additional ORR land declared excess by the DOE and made available for urban expansion by the City (City of Oak Ridge 1989). Demand for buildable land on the ORR by the City of Oak Ridge represents another cumulative demand for ORR land. The site of the proposed residential development and golf course east of the ORR is land recently sold by the DOE to the City of Oak Ridge since adoption of the Comprehensive Plan.

5.16.1.2 Occupational and Public Health. The annual collective effective dose

equivalent from the existing ORR facilities to the population within 50 miles (80 kilometers) of the ORR is 52 person-rem (MMES 1994a). Added to this baseline, operation of the proposed SNF management facilities might contribute an additional 5 person-rem, and operation of the proposed Advanced Neutron Source facilities might contribute an additional 4.3 person-rem (MMES 1992c), resulting in a cumulative effective dose of 61 person-rem to the population within 50 miles of the ORR.

The annual collective effective dose equivalent from the existing ORR facilities to a potential maximally exposed individual at the site boundary is 3.3 millirem per year. Operation of the proposed SNF management facilities might contribute an additional 6.2 millirem per year, resulting in a cumulative annual dose of 9.5 millirem per year to this maximally exposed individual.

The total annual baseline worker dose seen from normal ORR operations is about 48 person-rem. The total annual SNF management facility worker dose is expected to be roughly 32 person-rem. Hence, the cumulative annual dose might be 80 person-rem.

Over the planned 40-year operational lifetime of the SNF management facility, a total population dose of roughly 2,500 person-rem will be observed from continuous operation of the existing ORR facilities and the SNF management facility. This equates to a total health detriment (the summated risk of fatal cancer, nonfatal cancer, and genetic effects) of 1.8 over the 40-year span. For the maximally exposed individual, a total dose of 380 millirem will be observed over the 40-year period, which equates to a total detriment of 2.8 x 10-4. For the SNF management worker, a total dose of 3,200 person-rem will be observed over the 40-year span; this corresponds to a total health detriment of 1.8.

Additional radiological impacts are not expected from operation of the proposed Expended Core Facility. Analysis has shown that the dose to all individuals considered (workers and offsite individuals) from Oak Ridge Expended Core Facility operations might be much less than 1 millirem per year.

5.16.1.3 Noise. Cumulative increases in noise levels from the proposed SNF

management facilities, the proposed Expended Core Facility, and the proposed Advanced Neutron Source facilities would be limited to temporary, minor construction noise and small increases in traffic noise occurring along various access routes to the ORR due to increases in employment. This increase is not expected to result in any increased annoyance to the public. Noise levels from other planned activities have not yet been determined. Each would, at a minimum, involve temporary periods of construction noise, but information on operational noise is not available.

5.16.1.4 Groundwater and Surface Water Resources. Operation of the proposed SNF

management facilities would require the withdrawal of an estimated 4 million gallons per year (15 million liters per year) of groundwater. Operation of the proposed Expended Core Facility would require the withdrawal of an estimated additional 2 million gallons per year (8 million liters per year). Although the specific water demands of the proposed Advanced Neutron Source facility and other proposed activities are not known, the combined water demands would likely represent a small percentage of the total average discharge of the Clinch River, as measured at Melton Hill Dam, of 5,300 cubic feet per second (150 cubic meters per second).

Discharges of wastewater from the SNF management facilities would increase the flow of Grassy Creek by an estimated average of less than 1 percent. Discharge points would be selected in accordance with permit requirements to minimize impacts to surface water resources. The sanitary wastewater and cooling water from the Advanced Neutron Source facility would be discharged to separate streams and therefore would not contribute to cumulative impacts to Grassy Creek. Discharges from other planned facilities have not yet been designed. There are no expected cumulative impacts to groundwater quality and quantity.

5.16.1.5 Biotic Resources. Construction of the proposed SNF management facilities

would require the disturbance of approximately 90 acres (0.36 square kilometer) of mostly forested terrestrial habitat, construction of the proposed Expended Core Facility would require the disturbance of an additional 30 acres (0.12 square kilometer), and construction of the proposed Advanced Neutron Source facilities would require the disturbance of an additional 75 to 115 acres (0.30 to 0.46 square kilometer). This would result in a combined conversion of as much as 235 acres (0.94 square kilometer) of forested habitat to developed uses. Additional areas of forested habitat on the ORR would be lost during construction of activities proposed in the Five-Year Plan. Additionally, losses of similar forested habitat off of the ORR are anticipated due to future construction in the City of Oak Ridge. For example, construction of the proposed golf course and residential development east of the ORR by the City of Oak Ridge would result in the conversion of several hundred acres of forested habitat to structures and lawns.

The total losses would represent only a small percentage of the total forested area on the ORR and in the surrounding vicinity. However, the several scattered areas of habitat disturbance planned for the ORR, including that associated with the SNF management facilities, would increase fragmentation of the relatively contiguous forest cover over much of the ORR. This fragmentation could affect the suitability of the forested habitat on the ORR for several species.

5.16.1.6 Air Resources. The potential cumulative air emissions from the proposed SNF

management facility, Expended Core Facility, and Advanced Neutron Source facilities would not result in an exceedance of the National Ambient Air Quality Standards or Tennessee state criteria. Also, there would be no exceedance of Federal National Emissions Standards for Hazardous Air Pollutants or DOE radiological standards. Air emission data for the other planned activities (Five-Year Plan or offsite) are not available.

5.16.1.7 Socioeconomics. Operation of the proposed SNF management facilities might

generate up to 800 new jobs during the year 2005. Operation of the proposed Expended Core Facility might generate up to 562 additional jobs during that year, resulting in a combined increase of up to 1,362 new jobs. The 16,980 jobs presently forecasted for the ORR in the year 2005 would be increased by 8 percent, to as much as 18,342 jobs. The 360,000 jobs presently forecasted for the surrounding area in the year 2005 might be increased by less than 1 percent, to as much as 361,352 jobs. Additional employment increases could also result from the proposed Advanced Neutron Source facility project, activities proposed in the Five-Year Plan, and new offsite activities, but specific estimates are not available.

The proposed SNF management facilities could cause cumulative growth-inducing effects when coupled with the proposed Advanced Neutron Source facilities or with other planned activities on the ORR. Previous actions at the ORR have had a modest effect on long-term growth and productivity in Knox County and Loudon County, but they did not have a greater effect on long-term growth and productivity in Anderson County and Roane County.

5.16.1.8 Transportation. For transportation, minor levels of service changes might occur

due to employment increases associated with the proposed SNF management facilities, the proposed Expended Core Facility, the proposed Advanced Neutron Source facility, some of the proposed onsite activities in the Five-Year Plan, and some of the proposed offsite activities. Maps included in the Five-Year Plan show several road improvements on the ORR to accommodate presently projected regional traffic increases.

5.16.1.9 Waste Management. Operation of the proposed SNF management facilities

would generate an estimated 203 cubic meters per year of low-level waste and an estimated 16 cubic meters per year of transuranic waste. Operation of the proposed Expended Core Facility would generate an additional 425 cubic meters of low-level waste (for a combined total by both facilities of 628 cubic meters) but would not generate any additional transuranic waste. No other radioactive waste, including high-level waste or mixed waste, would be generated by either facility. Although it is known that the proposed Advanced Neutron Source facility would generate low-level waste, comparable quantitative data are not available for it or for offsite activities, or for activities proposed in the Five-Year Plan. All wastes generated by the proposed SNF management facilities and other planned activities on the ORR would be treated and disposed of in accordance with all applicable Federal and state regulations.

5.16.1.10 Other Resources. The absence of impacts, or the potential for very minimal

impacts, from the proposed SNF management facilities to cultural resources, aesthetic and scenic resources, utilities, and geologic resources ensures that their potential contribution to cumulative impacts affecting these resources would be negligible. No further analysis is necessary.

5.16.2 Regionalization Alternative

The Regionalization Alternative would have similar or fewer cumulative impacts than the Centralization Alternative. Generally, the alternative requires less construction and smaller scale operations, and the potential for cumulative impacts is therefore less.

5.17. Adverse Environmental Effects That Cannot Be Avoided

5.17.1 Overview

This section discusses potentially unavoidable adverse impacts to the environment resulting from construction and operation of the proposed spent nuclear fuel (SNF) management facilities at the Oak Ridge Reservation (ORR) under the Centralization and Regionalization Alternatives. Unavoidable adverse impacts are impacts that cannot be mitigated by changes in project design, operation, construction, or by other measures.

5.17.2 Centralization Alternative

Operation of the proposed SNF facilities at the ORR under the Centralization Alternative would increase the radiation dose rate to the maximally exposed individual by 6.2 millirem per year, resulting in a 34 percent increase in cancer risk to this individual from ORR operations. These cancer risks still would be minimal. The number of fatal cancers resulting from 1 year of operations on the ORR from all sources (including baseline and the SNF facilities) would be 3.0 x 10-2, the number of nonfatal cancers per year would be 5.9 x 10-3, and the number of genetic effects per year would be 7.7 x 10-3.

Construction of the proposed SNF management facilities would require the disturbance of approximately 90 acres (0.36 square kilometer) of mostly forested undeveloped land and the long-term dedication of approximately 85 acres (0.34 square kilometer) of land. Although this represents less than 1 percent of the undeveloped land on ORR, it would eliminate potential foraging and nesting habitat and would destroy plant species in the area. It would also require the dedication of a reasonably level land parcel that could have otherwise accommodated other construction projects.

The potential impacts from the Centralization Alternative to the other environmental resources discussed in Chapter 5 are not unavoidable adverse impacts.

5.17.3 Regionalization Alternative

Potential unavoidable adverse impacts associated with the Regionalization Alternative would resemble those discussed above for the Centralization Alternative. The extent of the impacts could be less due to the reduced land requirements, reduced extent of construction disturbance, and reduced scale of operations.

5.18 Relationship Between Short-Term Use of the Environment and

the Maintenance of Long-Term Productivity

Implementation of any of the SNF management alternatives would cause some adverse impacts to the environment and permanently commit certain resources. These resources include use of the environment and those associated with construction and operation of the SNF management facilities.

The proposed alternatives for SNF management would require the short-term use of resources including energy, construction materials, and labor in order to achieve the objective of safety managing SNF to minimize the risk to workers, the public, and the environment.

The premature shutdown of research reactors due to a lack of sufficient SNF interim storage space under the No Action Alternative could have an impact upon the ORR regional communities. The ORR High Flux Isotope Reactor is an important source of radiopharmaceuticals. The reactors are unique research and training facilities for researchers and students in many fields of research and development: materials science, environmental science, physics, biology, and electronics.

Development of new SNF interim management facilities would commit lands to those uses from the time of construction through the cessation of operations, at which time the facilities could be converted to other uses or decontaminated, decommissioned, and the site restored to its original land use. Existing SNF management facilities could also be converted to other uses, or the lands could be restored following decommissioning.

5.19. Irreversible and Irretrievable Commitments of Resources

5.19.1 Overview

This section discusses the irreversible and irretrievable commitments of resources resulting from the use of materials that cannot be recovered or recycled, or that must be consumed or reduced to irrecoverable forms.

5.19.2 Centralization Alternative

Construction and operation of spent nuclear fuel (SNF) management facilities under the Centralization Alternative would require commitments of electrical energy, fuel, concrete, steel, sand, gravel, and miscellaneous chemicals. Most of the water that would be withdrawn from the Clinch River to operate the SNF management facilities would be returned to surface water in the Clinch River watershed, although some evaporative losses would be unavoidable. The land dedicated to the SNF management facilities could become available for other urban uses following closure and decommissioning. However, the soils on the site would have to be amended to support land uses such as agriculture, forestry, or wildlife management.

5.19.3 Regionalization Alternative

Irreversible and irretrievable commitments of resources associated with the Regionalization Alternative would resemble those discussed above for the Centralization Alternative. However, the extent of these resource commitments could be less due to the reduced land requirements and reduced scale of operations.

5.20 Potential and Mitigation Measures

5.20.1 Pollution Prevention

The DOE Oak Ridge Field Office established a Waste Minimization and Pollution Prevention Awareness Plan to reduce the quantity and toxicity of hazardous, mixed, and radioactive wastes generated at Oak Ridge. The plan is designed to reduce the possible pollutant releases to the environment and thus increase the protection of employees and the public. All contractors and users that exceed the EPA criteria for small-quantity generators are establishing their own waste minimization and pollution prevention awareness programs. Contractor programs ensure that waste minimization activities are in accordance with Federal, state, and local environmental laws and regulations, and DOE Orders.

Additional goals include the promotion and use of nonhazardous materials, establishment of a baseline of waste generation data, calculations of annual reductions of waste generated, and implementation of recycling programs. Goals also include incorporation of waste minimization concepts and technologies in planning and design of new processes and facilities, and in upgrades of existing facilities. A waste minimization task force composed of representatives from each contractor has been established to coordinate waste minimization and pollution awareness activities.

5.20.2 Potential Mitigation Measures

Potential impact avoidance and mitigation measures are addressed in Chapter 5, Sections 1 through 15 as appropriate.

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7.0 ABBREVIATIONS AND ACRONYMS

yC	degrees Celsius
CFR	Code of Federal Regulations
Ci	curie(s)
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
EIS	environmental impact statement
ECF	Expended Core Facility
EPA	U.S. Environmental Protection Agency
yF	degrees Fahrenheit
FEMA	Federal Emergency Management Agency
g	gram
gal	gallon(s)
hr	hour
INEL	Idaho National Engineering Laboratory
kg	kilogram
km	kilometer
kv	kilovolt
y	liter
m	meter
m3	cubic meter
mi	mile
mi2	square mile
min	minute
mph	miles per hour
mR	milliroentgen
mrem	millirem
MTHM	metric tons of heavy metal
MW	Megawatt
nCi	nanocurie
NEPA	National Environmental Policy Act
NRC	Nuclear Regulatory Commission
NTS	Nevada Test Site
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PCB	polychlorinated biphenyl
pCi	picocurie(s)
PEIS	Programmatic Environmental Impact Statement
PM10	particulate matter less than 10 microns in diameter
ppm	parts per million
RCRA	Resource Conservation and Recovery Act
SNF	spent nuclear fuel
SRS	Savannah River Site
TVA	Tennessee Valley Authority
ug	micrograms
USGS	U.S. Geological Survey
yr	year

Appendix G

Acronyms/Abbreviations

CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
EA	environmental assessment
ECF	Expended Core Facility
EIS	Environmental Impact Statement
HS	Hanford Site
INEL	Idaho National Engineering Laboratory
MEI	maximally exposed individiual
MTHM	metric tons of heavy metal
NNPP	Naval Nuclear Propulsion Program
NTS	Nevada Test Site
ORR	Oak Ridge Reservation
PEIS	Programmatic Environmental Impact Statement
PUREX	Plutonium Uranium Extraction
SNF	spent nuclear fuel
SRS	Savannah River Site
TRIGA	training, research, and isotope reactors built by General Atomics

Appendix H

Glossary

Terms in this glossary are defined based on the context in which they are used in this EIS.

100-year flood : A flood event of such magnitude it occurs, on average, every 100 years (equates to a 1 percent probability of occurring in any given year).

500-year flood : A flood event of such magnitude it occurs, on average, every 500 years (equates to a 0.2 percent probability of occurring in any given year).

abnormal condition : Any deviation from normal conditions.

accident : An unplanned sequence of events that results in undesirable consequences.

actinide : Any of a series of chemically similar, mostly synthetic, radioactive elements with atomic numbers ranging from actinium-89 through lawrencium-103.

alpha-emitter : A radioactive substance that decays by releasing an alpha particle.

alpha-low-level waste : Waste that was previously classified as transuranic waste but has a transuranic concentration lower than the currently established limit for transuranic waste. Low-level waste requires additional controls and special handling. This waste stream cannot be accepted for onsite disposal under the current waste acceptance criteria; therefore, it is special-case waste.

alpha particle : A positively charged particle ejected spontaneously from the nuclei of some radioactive elements. It is identical to a helium nucleus that has a mass number of 4 and an electrostatic charge of +2.

as low as reasonably achievable (ALARA) : A process by which a graded approach is applied to maintaining dose levels to workers and the public, and releases of radioactive materials to the environment as low as reasonably achievable.

atomic number : The number of positively charged protons in the nucleus of an atom and the number of electrons on an electrically neutral atom.

background radiation : Radiation from cosmic sources; naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear material), and global fallout as it exists in the environment from the testing of nuclear explosive devices.

baseline : For purposes of this EIS, the conditions projected to exist in June 1995, the scheduled date for the Record of Decision, against which the environmental consequences of the various alternatives are evaluated.

beta-emitter : A radioactive substance that decays by releasing a beta particle.

beta particle : A charged particle emitted from a nucleus during radioactive decay, with a mass equal to 1/1837 that of a proton. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a positron.

boiling water reactor : A type of nuclear reactor that uses fission heat to generate steam in the reactor to drive turbines and generate electricity.

breeder reactor : A type of nuclear reactor that creates more fissionable fuel than it uses.

by-product material : (a) Any radioactive material (except special nuclear material) yielded in, or made radioactive by, exposure to the radiation incident to the process of producing or utilizing special nuclear material, and (b) the tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content [Atomic Energy Act 11(e)]. By-product material is exempt from regulation under the Resource Conservation and Recovery Act.

calcination : The process of converting high-level waste to unconsolidated granules or powder (also called calcining).

calcine : The material produced by a calcination.

canning : The process of placing spent nuclear fuel in canisters to retard corrosion, contain radioactive releases, or control geometry.

capable fault : In part, a capable fault is one that may have had movement at or near the ground surface at least once within the past 35,000 years, or has had recurring movement within the past 500,000 years.
Further definition can be found in 10 CFR 100, Appendix A.

characterization : The determination of waste composition and properties, whether by review of process knowledge, nondestructive examination or assay, or sampling and analysis, generally done for the purpose of determining appropriate storage, treatment, handling, transport, and disposal requirements.

cladding : The outer jacket of fuel elements and targets usually made of aluminum, stainless steel, or zirconium alloy, used to prevent fuel corrosion and retain fission products during reactor operation, or to prevent releases into the environment during storage.

co-located workers : Workers in a fixed population outside the day-to-day process safety management controls of a given facility area. In practice, this fixed population is normally the workers at an independent facility area located some distance from the reference facility area.

committed dose equivalent (H50) : The dose equivalent to organs or tissues of reference that will be received from an intake of radioactive material by an individual during the 50-year period following the intake. The International Commission on Radiological Protection defines this as the committed equivalent dose.

committed effective dose equivalent (HE,50) : The sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues. The International Commission on Radiological Protection defines this as the committed effective dose.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) : A Federal law (also known as "Superfund") that provides a comprehensive framework to deal with past or abandoned hazardous materials. The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) provides for liability, compensation, cleanup, and emergency response for hazardous substances released into the environment that could endanger public health, welfare, or the environment, as well as the cleanup of inactive hazardous waste disposal sites. CERCLA has jurisdiction over any release or threatened release of any "hazardous substance" to the environment. Under CERCLA, the definition of "hazardous" is much broader than under the Resource Conservation and Recovery Act, and the hazardous substance need not be a waste. If a site meets the CERCLA requirements for designation, it is ranked along with other "Superfund" sites and listed on the National Priorities List. This ranking and listing is the U.S. Environmental Protection Agency's way of determining which sites have the highest priority for cleanup.

contact-handled waste : Packaged waste whose external surface dose rate does not exceed 200 millirem per hour.

contamination : The deposition of unwanted radioactive material on the surfaces of structures, areas, objects, or personnel.

coolant : A gas or liquid circulated through a nuclear reactor to remove or transfer heat.

core : The central portion of a nuclear reactor containing the fuel elements, moderator, neutron poisons, and support structures.

curie (Ci) : The basic unit used to describe the intensity of radioactivity in a sample of material. The curie is equal to 37 billion disintegrations per second, which is approximately the rate of decay of 1 gram of radium. A curie is also a quantity of any radionuclide that decays at a rate of 37 billion disintegrations per second.

decay, radioactive : The decrease in the amount of any radioactive material with the passage of time, due to the spontaneous emission from the atomic nuclei of either alpha or beta particles, often accompanied by gamma radiation (see half-life, radioactive).

decommissioning : The process of removing a facility from operation, followed by decontamination, entombment, dismantlement, or conversion to another use.

decontamination : The actions taken to reduce or remove substances that pose a substantial present or potential hazard to human health or the environment, such as radioactive contamination from facilities, soil, or equipment by washing, chemical action, mechanical cleaning, or other techniques.

degraded (spent nuclear fuel) : Spent nuclear fuel whose external cladding has cracked, pitted, corroded, or potentially allows the leakage of radioactive materials.

DOE orders : Requirements internal to the U.S. Department of Energy (DOE) that establish DOE policy and procedures, including those for compliance with applicable laws.

DOE site boundary : A geographic boundary within which public access is controlled and activities are governed by the U.S. Department of Energy (DOE) and its contractors, not by local authorities. Based on the definition of exclusion zone, a public road traversing a DOE site is considered to be within the DOE site boundary if DOE or the site contractor has the capability to control the road at any time necessary.

dosage : The concentration-time profile for exposure to toxicological hazards.

dose (or radiation dose) : A generic term that means absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or total effective dose equivalent, as defined elsewhere in this glossary.

driver fuel : These fuel tubes or assemblies usually contain enriched uranium, plutonium, or thorium materials, which can be fissioned (or split) by neutrons. Because this fuel drives neutron bombardment of targets in a production or research reactor, these fuels are called drivers.

dry storage : Storage of spent nuclear fuel in environments where the fuel is not immersed in liquid for purposes of cooling and/or shielding.

effective dose equivalent (EDE) : The sum of the products of the dose equivalent to the organ or tissue and the weighting factors applicable to each of the body organs or tissues that are irradiated. It includes the dose from radiation sources internal and/or external to the body and is expressed in units of rem. The International Commission on Radiation Protection defines this as the effective dose.

enriched uranium : Uranium that has greater amounts of the fissionable isotope uranium-235 than occurs naturally. Naturally occurring uranium is 0.72 percent uranium-235.

environmental monitoring : The process of sampling and analysis of environmental media in and around a facility being monitored for the purpose of (a) confirming compliance with performance objectives, and (b) early detection of any contamination entering the environment to facilitate timely remedial action.

existing facilities : Facilities that are projected to exist as of the Record of Decision for this EIS, scheduled for June 1995.

external accident : Accidents initiated by manmade energy sources not associated with operation of a given facility. Examples include airplane crashes, induced fires, transportation accidents adjacent to a facility, and so forth.

facility worker : Any worker whose day-to-day activities are controlled by process safety management programs and a common emergency response plan associated with a facility or facility area. This definition includes any individual within a facility/facility area or its 0.4-mile exclusion zone. This definition can also include those transient individuals or small populations outside the exclusion zone but inside the radius defined by the maximally exposed co-located worker if reasonable efforts to account for such people have been made in the facility or facility area emergency plan. For facility accident analyses, the facility worker is defined as an individual located 100 meters (328 feet) downwind of the facility location where an accidental release occurs.

fissile material : Although sometimes used as a synonym for fissionable material, this term has acquired a more restricted meaning; namely, any material fissionable by thermal (slow) neutrons. The three primarily fissile materials are uranium-233, uranium-235, and plutonium-239.

fission : The splitting of a nucleus into at least two other nuclei and the release of a relatively large amount of energy. Two or three neutrons are usually released during this type of transformation.

fission products : The nuclei (fission fragments) formed by the fission of heavy elements, plus the nuclides formed by the fission fragments' radioactive decay.

fissionable material : Commonly used as a synonym for fissile material, the meaning of this term has been extended to include material that can be fissioned by fast neutrons, such as uranium-238.

gamma-emitter : A radioactive substance that decays by releasing gamma radiation.

gamma ray (gamma radiation) : High-energy, short wavelength electromagnetic radiation (a packet of energy) emitted from the nucleus. Gamma radiation frequently accompanies alpha and beta emissions and always accompanies fission. Gamma rays are very penetrating and are best stopped or shielded against by dense materials, such as lead or uranium. Gamma rays are similar to x-rays, but are usually more energetic.

geologic repository : A system that is intended to be used for, or may be used for, the disposal of radioactive waste or spent nuclear fuel in excavated geologic media. A geologic repository includes (a) the geologic repository operations area, and (b) the portion of the geologic setting that provides isolation. A near-surface disposal area is not a geologic repository.

groundwater : Generally, all water contained in the ground. Water held below the water table available to freely enter wells.

grouting : Grouting is the process of immobilizing or fixing solid forms of waste so they can be more safely stored or disposed.

half-life : The time in which half the atoms of a particular radioactive substance disintegrate to another nuclear form. Measured half-lives vary from millionths of a second to billions of years. Also called physical half-life.

hazardous chemical : A term defined under the Occupational Safety and Health Act and the Emergency Planning and Community Right-to-Know Act as any chemical that is a physical hazard or a health hazard.

hazardous material : A substance or material, including a hazardous substance, which has been determined by the U.S. Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce.

hazardous substance : Any substance that when released to the environment in an uncontrolled or unpermitted fashion becomes subject to the reporting and possible response provisions of the Clean Water Act and the Comprehensive Environmental Response, Compensation, and Liability Act.

hazardous waste : Under the Resource Conservation and Recovery Act, a solid waste, or combination of solid wastes, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may (a) cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversibile, illness; or (b) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed. Source, special nuclear material, and by-product material, as defined by the Atomic Energy Act, are specifically excluded from the definition of solid waste.

heterogeneous : Pertaining to a substance having different characteristics in different locations. A synonym is nonuniform.

high-efficiency particulate air (HEPA) filter : A filter with an efficiency of at least 99.95 percent used to separate particles from air exhaust streams prior to releasing that air into the atmosphere.

high-level waste : The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly from reprocessing and any solid waste derived from the liquid that contains a combination of transuranic and fission product nuclides in quantities that require permanent isolation. High-level waste may include other highly radioactive material that the U.S. Nuclear Regulatory Commission, consistent with existing law, determines by rule requires permanent isolation.

hot cell/hot cell facility : A heavily shielded enclosure for handling and processing (by remote means or automatically), or storing highly radioactive materials.

hydrogeology : The study of the geological factors relating to water.

hydrology : The study of water, including groundwater, surface water, and rainfall.

incineration : The efficient burning of combustible solid and liquid wastes to destroy organic constituents and reduce the volume of the waste. Incinerators are designed to burn with an extremely high efficiency. The greater the burning efficiency, the cleaner the air emission. Incineration of radioactive materials does not destroy the radionuclides but does significantly reduce the volume of these wastes. High-efficiency particulate air (HEPA) filters are used to prevent radionuclides and heavy metals from going out of the stack and into the atmosphere.

inconel : A metal alloy containing nickel, chromium, and iron, which exhibits good resistance to corrosion in aqueous environments.

interim action (NEPA) : An action that may be undertaken while work on a required program EIS is in progress, and the action is not covered by an existing program statement. An interim action may not be undertaken unless such action: (a) is justified independently of the program; (b) is itself accompanied by an adequate EIS or has undergone other NEPA review; and (c) will not prejudice the ultimate decision on the program. Interim action prejudices the ultimate decision on the program when it tends to determine subsequent development or limit alternatives.

intermittent surface water : A stream, creek, or river that does not contain water during part or all of the year.

internal accidents : Accidents that are initiated by man-made energy sources associated with the operation of a given facility. Examples include process explosions, fires, spills, criticalities, and so forth.

involved worker : Workers that would be involved in a proposed action as opposed to workers that would be on the site of a proposed action but not involved in the action.

isotope : One of two or more atoms with the same number of protons, but different numbers of neutrons, in their nuclei. Thus, carbon-12, carbon-13, and carbon-14 are isotopes of the element carbon, the numbers denoting the approximate atomic weights. Isotopes have very nearly the same chemical properties, but often different physical properties (for example, carbon-12 and -13 are stable, carbon-14 is radioactive).

life cycle : The entire time period from generation to permanent disposal or elimination of waste.

liquid metal cooled breeder reactor : A reactor that creates more fissionable material than it consumes and uses liquid metal as a coolant. Liquid sodium is a common metal used to cool this type of reactor.

liquid metal fast breeder reactor : A reactor that operates using a type of fission known as fast fission where the neutrons that are used to split the atoms are not slowed down or moderated as is usually the case with normal fission. It creates more fissionable material than it consumes and uses liquid metal as a coolant. Liquid sodium is a common metal used to cool this type of reactor.

long-term storage : The storage of hazardous waste (a) onsite (a generator site) for a period of 90-days or greater, other than in a satellite accumulation area, or (b) offsite in a properly managed treatment, storage, or disposal facility for any period of time.

low-level waste : Waste that contains radioactivity and is not classified as high-level waste, transuranic waste, or spent nuclear fuel. Test specimens of fissionable material irradiated for research and development only, and not for the production of power or plutonium, may be classified as low-level waste, provided the concentration of transuranic elements is less than 100 nanocuries per gram of waste.

major radionuclides : The radioisotopes that together comprise 95 percent of the total curie content of a waste package by volume and have a half-life of at least 1 week. Radionuclides that are important to a facility's radiological performance assessment and/or a safety analysis and are listed in the facility's waste acceptance criteria are considered major radionuclides.

management (of spent nuclear fuel) : Emplacing, operating, and administering facilities, transportation systems, and procedures to assure safe and environmentally responsible handling and storage of spent nuclear fuel pending (and in anticipation of) a decision on ultimate disposition.

maximally exposed co-located worker (MCW) : A hypothetical individual defined to allow dose or dosage comparison with numerical criteria for co-located workers. This individual is located at whichever is the greater of 0.4 miles from the facility area boundary (that is, the exclusion zone boundary) or 75 percent of the distance to the nearest independent facility area (that is, the low population zone boundary). The MCW is irrelevant if the DOE site boundary is closer than the MCW location.

maximally exposed individual (MEI) : A hypothetical individual defined to allow dose or dosage comparison with numerical criteria for the public. This individual is located at the point on the DOE site boundary nearest to the facility in question. Sometimes called maximally exposed offsite individual (MOI).

maximally exposed offsite individual (MOI) : A hypothetical individual defined to allow dose or dosage comparison with numerical criteria for the public. This individual is located at the point on the DOE site boundary nearest to the facility in question. Sometimes called the maximally exposed individual (MEI).

maximum contaminant level (MCL) : Under the Safe Drinking Water Act, the maximum permissible concentrations of specific constituents in drinking water that is delivered to any user of a public water system that serves 15 or more connections and 25 or more people. The standards set as maximum contaminant levels take into account the feasibility and cost of attaining the standard.

metric tons of heavy metal (MTHM) : Quantities of unirradiated and spent nuclear fuel and targets are traditionally expressed in terms of metric tons of heavy metal (typically uranium), without the inclusion of other materials, such as cladding, alloy materials, and structural materials. A metric ton is 1,000 kilograms, which is equal to about 2,200 pounds.

millirem : One thousandth of a rem (see rem).

mixed waste : Waste that contains both hazardous waste under the Resource Conservation and Recovery Act and source, special nuclear, or by-product material subject to the Atomic Energy Act of 1954.

mitigation : Those actions that avoid impacts altogether, minimize impacts, rectify impacts, reduce or eliminate impacts, or compensate for the impact.

nanocurie : One billionth of a curie (see curie).

National Priorities List (NPL) : A formal listing of the nation's most hazardous waste sites, as established under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), that have been identified for remediation.

natural phenomena accidents : Accidents that are initiated by phenomena such as earthquakes, tornadoes, floods, and so forth.

near-surface disposal : Disposal in the uppermost portion of the earth, approximately 30 meters. Near-surface disposal includes disposal in engineered facilities that may be built totally or partially above-grade provided that such facilities have protective earthen covers. A near-surface disposal facility is not considered a geologic repository.

nitrogen oxides (NOx) : Gases formed in great part from atmospheric nitrogen and oxygen when combustion takes place under conditions of high temperature and high pressure; considered a major air pollutant. Two major nitrogen oxides, nitric oxide (NO) and nitrogen dioxide (NO2) are important airborne contaminants. In the presence of sunlight, nitric oxide combines with atmospheric oxygen to produce nitrogen dioxide, which in high enough concentrations can cause lung damage.

normal conditions : All activities associated with a facility mission, whether operation, maintenance, storage, and so forth, which are carried out within a defined envelope. This envelope can be design process conditions, performance in accordance with procedure, and so forth.

normal operation : All normal conditions and those abnormal conditions that frequency estimation techniques indicate occur with a frequency greater than 0.1 events per year.

NOx : A generic term used to describe the oxides of nitrogen (see nitrogen oxides).

nuclear criticality : A self-sustaining chain reaction, which releases neutrons and energy, and generates radioactive by-product material.

nuclear fuel : Materials that are fissionable and can be used in nuclear reactors to make energy.

nuclide : A general term referring to all known isotopes, both stable (279) and unstable (about 5,000), of the chemical elements.

off-link doses : Doses to members of the public within 800 meters (2,625 feet) of a road or railway.

offsite facility : A facility located at a different site or location than the shipper.

on-link doses : Doses to members of the public sharing a road or railway.

onsite : The same or geographically contiguous property that may be divided by public or private right-of-way, provided the entrance and exit between the properties is at a cross-roads intersection, and access is by crossing as opposed to going along the right-of-way. Non-contiguous properties owned by the same person but connected by a right-of-way that he/she controls and to which the public does not have access is also considered onsite property.

onsite facilities : Buildings and other structures, their functional systems and equipment, and other fixed systems and equipment installed onsite.

operator : The organization that operates a facility.

passivation : The process of making metals inactive or less chemically reactive. For example, to passivate the surface of steel by chemical treatment.

perennial stream : A water course that flows year-round.

performance objectives : Parameters within which a facility must perform to be considered acceptable.

permeability : The degree of ease with which water can pass through a rock or soil.

playa : The shallow central basin of a desert plain in which water gathers and then evaporates.

picocurie : One trillionth of a curie (see curie).

pollutant migration : The movement of a contaminant away from its initial source.

pollution prevention : The use of any process, practice, or product that reduces or eliminates the generation and release of pollutants, hazardous substances, contaminants, and wastes, including those that protect natural resources through conservation or more efficient utilization.

polychlorinated biphenyls (PCBs) : A class of chemical substances formerly manufactured as an insulating fluid in electrical equipment that is highly toxic to aquatic life. In the environment, PCBs exhibit many of the characteristics of dichloro diphenyl trichloroethane (DDT); they persist in the environment for a long time and accumulate in animals.

population dose : The overall dose to the offsite population.

porosity (n) : Porosity is an index of relative pore volume. It is the total unit volume of the soil or rock divided into the void volume.

pressurized water reactor : A nuclear power reactor that uses water under pressure as a coolant. The water boiled to generate steam is in a separate system.

probable maximum flood : The largest flood for which there is any reasonable expectancy in a specific area. The probable maximum flood is normally several times larger than the largest flood of record.

process knowledge : The set of information that is used by trained and qualified individuals who are cognizant of the origin, use, and location of waste-generating materials and processes in sufficient detail so as to certify the identity of the waste.

processing (of spent nuclear fuel) : Applying a chemical or physical process designed to alter the characteristics of the spent nuclear fuel matrix.

production reactor : A nuclear reactor that is used to irradiate target material to produce special nuclear material or by-product material.

public : Anyone outside the DOE site boundary at the time of an accident or during normal operation. With respect to accidents analyzed in this EIS, anyone outside the DOE site boundary at the time of an accident.

rad : The special unit of absorbed dose. One rad is equal to an absorbed dose of 100 ergs/gram.

radiation (ionizing radiation) : Alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. Radiation, as it is used here, does not include nonionizing radiation such as radio- or microwaves, or visible, infrared, or ultraviolet light.

radiation worker : A worker who is occupationally exposed to ionizing radiation and receives specialized training and radiation monitoring devices to work in such circumstances.

radioactive waste : Waste that is managed for its radioactive content.

radioactivity : The property or characteristic of material to spontaneously "disintegrate" with the emission of energy in the form of radiation. The unit of radioactivity is the curie (or becquerel).

radioisotope : An unstable isotope of an element that decays or disintegrates spontaneously, emitting radiation. Approximately 5,000 natural and artificial radioisotopes have been identified.

radiological survey : The evaluation of the radiation hazard accompanying the production, use, or existence of radioactive materials under a specific set of conditions. Such evaluation customarily includes a physical survey of the disposition of materials and equipment, measurements or estimates of the levels of radiation that may be involved, and a sufficient knowledge of processes affecting these materials to predict hazards resulting from unexpected or possible changes in materials or equipment.

radionuclide : See radioisotope.

Record of Decision (ROD) : A public document that records the final decision(s) concerning a proposed action. The Record of Decision is based in whole or in part on information and technical analysis generated either during the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process or the National Environmental Policy Act (NEPA) process, both of which take into consideration public comments and community concerns.

recycling : Recycling techniques are characterized as use, reuse, and reclamation techniques (resource recovery). Use or reuse involves the return of a potential waste material either to the originating process as a substitute for an input material or to another process as an input material. Reclamation is the recovery of a useful or valuable material from a waste stream. Recycling allows potential waste materials to be put to a beneficial use rather than going to treatment, storage, or disposal.

regulated substances : A general term used to refer to materials other than radionuclides that are regulated by Federal, state, (or possibly local) requirements.

rem : The dosage of an ionizing radiation that will cause the same biological effect as 1 roentgen of x-ray or gamma-ray exposure.

remote-handled waste : Packaged waste whose external surface dose rate exceeds 200 millirem per hour.

remote handling : The handling of wastes from a distance so as to protect human operators from unnecessary exposure.

repository : A permanent deep geologic disposal facility for high-level or transuranic wastes and spent nuclear fuel.

reprocessing (of spent nuclear fuel) : Processing of reactor irradiated nuclear material (primarily spent nuclear fuel) to recover fissile and fertile material, in order to recycle such materials primarily for defense programs. Historically, reprocessing has involved aqueous chemical separations of elements (typically uranium or plutonium) from undesired elements in the fuel.

research reactor : A nuclear reactor used for research and development.

Resource Conservation and Recovery Act (RCRA) : A Federal law addressing the management of waste. Subtitle C of the law addresses hazardous waste under which a waste must either be "listed" on one of the U.S. Environmental Protection Agency's (EPA's) hazardous waste lists or meet one of EPA's four hazardous characteristics of ignitability, corrosivity, reactivity, or toxicity, as measured using the toxicity characterization leaching procedure (TCLP). Cradle-to-grave management of wastes classified as RCRA hazardous wastes must meet stringent guidelines for environmental protection as required by the law. These guidelines include regulation of transport, treatment, storage, and disposal of RCRA defined hazardous waste. Subtitle D of the law addresses the management of nonhazardous, nonradioactive, solid waste such as municipal wastes.

retrieval : The process of recovering wastes that have been stored or disposed of onsite so they may be appropriately characterized, treated, and disposed of.

risk : Quantitative expression of possible loss that considers both the probability that a hazard causes harm and the consequences of that event.

safety analysis report : A report, prepared in accordance with DOE Orders 5481.1B and 5480.23, that summarize the hazards associated with the operation of a particular facility and defines minimum safety requirements.

sanitary waste : Liquid or solid wastes that are generated as a result of routine operations of a facility and are not considered hazardous or radioactive.

saturated zone : That part of the earth's crust in which all naturally occurring voids are filled with water.

scaling factor : A multiplier that allows the inference of one radionuclide concentration from another that is more easily measured.

scientific notation : A notation adopted by the scientific community to deal with very large and very small numbers by moving the decimal point to the right or left so that only one number above zero is to the left of the decimal point. Scientific notation uses a number times 10 and either a positive or negative exponent to show how many places to the left or right the decimal place has been moved. For example, in scientific notation, 120,000 would be written as 1.2 x 105, and 0.000012 would be written as 1.2 x 10-5. In a variation of scientific notation often used in computer printouts, the multiplication sign and number 10 are replaced by the letter E. The above numbers would be written as 1.2E5 and 1.2E-5, respectively.

segregation : The process of separating (or keeping separate) individual waste types and/or forms in order to facilitate their cost-effective treatment and storage or disposal.

seismicity : The phenomenon of earth movements; seismic activity. Seismicity is related to the location, size, and rate of occurrence of earthquakes.

seiche : A wave that oscillates in partially or totally enclosed bodies of water from a few minutes to a few hours, caused by seismic or atmospheric disturbances.

sole source aquifer : A designation granted by the U.S. Environmental Protection Agency when groundwater from a specific aquifer supplies at least 50 percent of the drinking water for the area overlying the aquifer. Sole-source aquifers have no alternative source or combination of sources that could physically, legally, and economically supply all those who obtain their drinking water from the aquifer. Sole-source aquifers are protected from federally financially assisted activities determined to be potentially unhealthy for the aquifer.

solid waste : Any garbage, refuse, or sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations and from community activities. It does not include solid or dissolved material in domestic sewage, or solid or dissolved materials in irrigation return flows or industrial discharges, which are point sources subject to permits under Section 402 of the Federal Water Pollution Control Act, as amended, or source, special nuclear, or by-product material as defined by the Atomic Energy Act of 1954, as amended [Public Law 94-580, 1004(27) (Resource Conservation and Recovery Act)].

solvents : Liquid chemicals, usually organic compounds, that are capable of dissolving another substance. Exposure to some organic solvents can produce toxic effects on body tissues and processes.

source material : (a) Uranium, thorium, or any other material that is determined by the U.S. Nuclear Regulatory Commission pursuant to the provisions of the Atomic Energy Act of 1954, Section 61, to be source material; or (b) ores containing one or more of the foregoing materials, in such concentration as the U.S. Nuclear Regulatory Commission may by regulation determine from time-to-time [Atomic Energy Act 11(z)]. Source material is exempt from regulation under to Resource Conservation and Recovery Act.

SOx : A generic term used to describe the oxides of sulfur. The combination of sulfur oxides with water vapor produces acid rain (see sulfur oxides).

special-case commercial reactor spent nuclear fuel : Complete or partial spent nuclear fuel assemblies from commercial nuclear power plants that were to be used to support DOE-sponsored research and development programs. This includes spent nuclear fuel from development reactors (Shippingport, Peach Bottom Unit 1, and Fort St. Vrain); spent nuclear fuel used for destructive and nondestructive examination and testing; spent nuclear fuel remaining at the West Valley Demonstration Project; and spent nuclear fuel remnants (Three-Mile Island Unit 2).

special nuclear material : (a) Plutonium, or uranium enriched in the isotope 233 or in the isotope 235, and any other material that the U.S. Nuclear Regulatory Commission, pursuant to the provisions of the Atomic Energy Act of 1954, Section 51, determines to be special nuclear material; or (b) any material artificially enriched by any of the foregoing, but does not include source material. Special nuclear material is exempt from regulation under the Resource Conservation and Recovery Act (RCRA).

specimen : A small sample of material (fuel or non-fuel) inserted into a reactor for testing to characterize the material's performance. Test specimens may be constructed of plant materials, reactor structural materials, or fuel materials.

spent nuclear fuel : Fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated. For the purposes of this EIS, spent nuclear fuel also includes uranium/neptunium target materials, blanket subassemblies, pieces of fuel, and debris.

stabilization (of spent nuclear fuel) : Actions taken to further confine or reduce the hazards associated with spent nuclear fuel, as necessary for safe management and environmentally responsible storage for extended periods of time. Activities that may be necessary to stabilize spent nuclear fuel include canning, processing, and passivation.

stakeholder : Any person or organization with an interest in or affected by DOE activities. Stakeholders may include representatives from Federal agencies, State agencies, Congress, Native American Tribes, unions, educational groups, industry, environmental groups, other groups, and members of the general public.

storage : The collection and containment of waste or spent nuclear fuel in such a manner as not to constitute disposal of the waste or spent nuclear fuel for the purposes of awaiting treatment or disposal capacity (that is, not short-term accumulation).

subsurface : The area below the land surface (including the vadose zone and aquifers).

sulfur oxides : Pungent, colorless gases formed primarily by the combustion of fossil fuels; considered major air pollutants; sulfur oxides may damage the respiratory tract as well as vegetation (see SOx).

target : A tube, rod, or other form containing material that, on being irradiated in a nuclear reactor would produce a designed end product (that is, uranium-238 produces plutonium-239 and neptunium-237 produces plutonium-238).

total effective dose equivalent : The sum of the external dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

transient : A change in the reactor coolant system temperature and/or pressure. Transients can be caused by adding or removing neutron poisons, by increasing or decreasing the electrical load on the turbine generator, or by accident conditions.

transuranic waste : Waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes, with half-lives greater than 20 years, per gram of waste, except for (a) high-level radioactive waste; (b) waste that the U.S. Department of Energy has determined, with the concurrence of the Administrator of the U.S. Environmental Protection Agency, does not need the degree of isolation required by 40 CFR 191; or (c) waste that the U.S. Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with 10 CFR 61.

transuranium radionuclide : Any radionuclide having an atomic number greater than 92.

tsunami : A huge ocean wave caused by an underwater earthquake or a volcanic eruption.

ultimate disposition : The final step in which a material is either processed for some use or disposed of.

vadose zone : The zone between the land surface and the water table. Saturated bodies, such as perched groundwater, may exist in the vadose zone. Also called the zone of aeration and the unsaturated zone.

vitrification : The process of immobilizing waste material that results in a glass-like solid.

volatile organic compound (VOC) : Chemical containing mainly carbon, hydrogen, and oxygen that readily evaporates at ambient temperature. Exposure to some organic compounds can produce toxic effects on body tissue and processes.

Volcanic Rift Zones : Linear belts of basaltic vents marked by open fissures, monoclines, and small normal faults. Volcanic rift zones were produced during the propagation of vertical molten basaltic dikes that fed surface eruptions.

vulnerabilities : Conditions or weaknesses that may lead to radiation exposure to the public, unnecessary or increased exposure to the workers, or release of radioactive materials to the environment. For example, some DOE facilities have had leakage from spent fuel storage pools, excessive corrosion of fuel causing increased radiation levels in the pool, or degradation of handling systems. Vulnerabilities are also caused by loss of institutional controls, such as cessation of facility funding or reductions in facility maintenance and control.

waste acceptance criteria (WAC) : The requirements specifying the characteristics of waste and waste packaging acceptable to a waste receiving facility; and the documents and processes the generator needs to certify that waste meets applicable requirements.

waste certification : A process by which a waste generator certifies that a given waste or waste stream meets the waste acceptance criteria of the facility to which the generator intends to transport waste for treatment, storage, or disposal. Certification is accomplished by a combination of waste characterization, documentation, quality assurance, and periodic audits of the certification program.

waste characterization : See characterization.

Waste Isolation Pilot Plant (WIPP) : A facility near Carlsbad, New Mexico, authorized to demonstrate safe disposal of defense-generated transuranic waste in a deep geologic medium.

waste management : The planning, coordination, and direction of those functions related to generation, handling, treatment, storage, transport, and disposal of waste, as well as associated surveillance and maintenance activities.

waste management facility : All contiguous land, structures, other appurtenances, and improvements on the land, used for treating, storing, or disposing of waste or spent nuclear fuel. A facility may consist of several treatment, storage, or disposal operational units (for example, one or more landfills, surface impoundments, or combinations of them).

waste management program : A systematic approach to organize, direct, document, and assess activities associated with waste generation, treatment, storage, or disposal. A waste management program consists of all the functional elements, organizations, and activities that comprise the system needed to properly manage waste. These functions and activities can be performed by various organizations.

waste management systems assessment : A systems assessment of the entire low-level waste management (or all of waste management) structure/program at a given site that considers treatment, storage, disposal, as well as onsite and offsite points of generation with an emphasis on optimization of all aspects of the operations, including, but not limited to, protection of human health and the environment, regulatory compliance, and cost effectiveness.

waste minimization : An action that economically avoids or reduces the generation of waste by source reduction, reducing the toxicity of hazardous waste, improving energy usage, or recycling. These actions will be consistent with the general goal of minimizing present and future threats to human health, safety, and the environment.

water pool : A type of facility usually used for the storage of irradiated nuclear materials and spent fuel. The water shields the material being stored while allowing it to be accessible for handling. Sometimes referred to as a water pit.

wet storage : Storage of spent nuclear fuel in a pool of water, generally for the purposes of cooling and/or shielding.

APPENDIX I Offsite Transportation of Spent Nuclear Fuel

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FIGURES

TABLES

Appendix I Offsite Transportation of Spent Nuclear Fuel

I-1 INTRODUCTION

This appendix summarizes the methods and results of analysis for determining the environmental impacts of spent nuclear fuel (SNF) transportation on public highways and rail systems outside the boundaries of U.S. Department of Energy (DOE) sites (offsite). The impacts are presented by alternative and include doses and health effects.

This appendix does not address the impacts of SNF transport within the boundaries of DOE sites (onsite). Onsite transport impacts are addressed in site-specific Appendices A through F. This appendix addresses offsite shipments of naval-type SNF stored at the Idaho Chemical Processing Plant as of June 1995 to storage locations at other sites as identified by certain alternatives. Transport of naval SNF from shipyards and prototypes to the equivalent expended core facility at the alternative sites are addressed in this EIS in Appendix D in Volume 1, along with transport of naval test specimens.

This appendix also includes the impacts of shipments of foreign research reactor SNF from the six points of entry identified in the Implementation Plan for this EIS (Hampton Roads, Virginia; Charleston, South Carolina; Savannah, Georgia; Seattle-Tacoma, Washington; Portland, Oregon; and Oakland, California) and the points of entry at the Military Ocean Terminal at Sunny Point, North Carolina; and Galveston, Texas. The six points of entry identified in the Implementation Plan were chosen using the following criteria: (a) adequacy of harbor and dock characteristics to satisfy the cask-carrying ship requirements, (b) availability of safe and secure lag storage, (c) adequacy of overland transportation systems from points of entry to the storage sites, (d) experience in safe and secure handling of hazardous cargo, (e) emergency preparedness status at the point of entry and nearby communities, and (f) proximity of the proposed storage sites. The Military Ocean Terminal at Sunny Point, North Carolina, was chosen because it was recently used for foreign research reactor SNF shipments. Galveston, Texas was chosen as a point of entry because it was on the Gulf Coast and has container-handling experience. A full range of alternative points of entry, including these and other points of entry, is being evaluated in the

Environmental Impact Statement on a Proposed Nuclear Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel,and no decision concerning the choice of points of entry will be made until both the Programmatic Spent Nuclear Fuel Management and the Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement and the Environmental Impact Statement on a Proposed Nuclear Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel are completed. The ocean-going portion of foreign research reactor SNF shipments and a detailed evaluation of point of entry activities are also not assessed in this appendix, but will be assessed in the Draft Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel.

The impacts of historical shipments of SNF to the Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, Oak Ridge Reservation, and the Nevada Test Site and cumulative transportation impacts are also discussed in this appendix. The historical impacts and cumulative impacts include shipments of naval SNF and test specimens.

I-2 TRANSPORTATION REGULATIONS

The regulatory standards for packaging and transport of SNF are designed to achieve four primary objectives:

- Protect persons and property from radiation emitted from packages during transportation, by specific limitations on the allowable radiation levels
- Provide proper containment of the SNF in the package (achieved by packaging design requirements based on performance-oriented packaging integrity tests and environmental criteria)
- Prevent nuclear criticality (an unplanned nuclear chain reaction that may occur as a result of concentrating too much fissile material in one place)
- Provide physical protection against theft and sabotage during transit.

The U.S. Department of Transportation regulates the transportation of hazardous materials (including SNF) in interstate and intrastate commerce by land, air, and on navigable water. As outlined in a 1979 Memorandum of Understanding with the U.S. Nuclear Regulatory Commission, the U.S. Department of Transportation specifically regulates the carriers of SNF and the conditions of transport, such as routing, handling and storage, and vehicle and driver requirements. The U.S. Department of Transportation also regulates the labeling, classification, and marking of all SNF packages.

The U.S. Nuclear Regulatory Commission regulates the packaging and transport of SNF for its licensees, which includes commercial shippers of SNF. In addition, under an agreement with the U.S. Department of Transportation, the U.S. Nuclear Regulatory Commission sets the standards for packages containing fissile materials and SNF.

The DOE, through its management directives, orders, and contractual agreements, assures the protection of public health and safety by imposing on its transportation activities standards equivalent to those of the U.S. Department of Transportation and the U.S. Nuclear Regulatory Commission. The DOE has authority, granted by a 1973 Memorandum of Understanding between the U.S. Department of Transportation and the Atomic Energy Commission, to certify DOE SNF packages. The DOE may design, procure, and certify its own SNF packages to be used by the DOE and its contractors if the packages provide equivalent safety to that provided in 10 CFR Part 71.

The U.S. Department of Transportation also has requirements that help to reduce transportation impacts. For example, there are requirements for drivers, routing, packaging, labeling, marking, and placarding. There are also requirements that specify the maximum dose rate associated with radioactive material shipments, which help to reduce incident-free transportation doses.

The Federal Emergency Management Agency is responsible for establishing policies for and coordinating civil emergency management, planning, and interaction with Federal executive agencies that have emergency response functions in the event of a SNF transportation incident. The Federal Emergency Management Agency coordinates Federal and state participation in developing emergency response plans and is responsible for the development of the interim Federal Radiological Emergency Response Plan. The Federal Radiological Emergency Response Plan is designed to coordinate Federal support to state and local governments, upon request, during the event of a SNF transportation incident.

The Interstate Commerce Commission is responsible for the regulation of the economic aspects of SNF transportation for land shipments. The Comission issues operating authorities to carriers and also monitors and approves freight rates.

Spent nuclear fuel is transported in Type B packages, which are designed and constructed to retain their radioactive contents in both normal and severe accident conditions.

Under normal conditions a cask must withstand:

- Hot [100F (38C)] and Cold [-40F (-40C)] temperatures
- External pressure changes from 3.5 to 20 pounds per square inch (24.5 to 140 kilopascal)
- Normal vibration experienced during transportation
- Simulated rainfall of 2 inches (5 centimeters) per hour for 1 hour
- Free drop from 1 to 4 feet (0.3 to 1.2 meters), depending on the package weight
- Compression loading (the greater of 5 times the weight of package or 1.85 pounds per square inch (12.75 kilopascal) times the vertical projected area of the package) applied uniformly to the top and bottom of the package for a period of 24 hours.
- Impact of a 13-pound (6-kilogram) steel cylinder with rounded ends dropped from 40 inches (1 meter) onto the most vulnerable surface of the cask.

Under accident conditions a cask must withstand:

- Free drop for 30 feet (9 meters) onto an unyielding surface in a way most likely to cause damage to the cask
- Free drop from 40 inches (1 meter) onto the end of a 6-inch-diameter (15-centimeter-diameter) vertical steel bar
- Exposure for not less than 30 minutes to temperatures of 1475F (802C)
- Immersion in at least 50 feet (15 meters) of water for 8 hours and, for criticality considerations, immersion in at least 3 feet (0.9 meters) of water for 8 hours in the attitude for which maximum leakage is expected.

Compliance with these requirements is demonstrated by using a combination of simple calculational methods, computer modeling techniques, or full-scale or scale-model testing of casks.

I-3 SNF TRANSPORTATION MODES AND ROUTES

I-3.1 SNF Transportation Routing Models

To assess incident-free and transportation accident impacts, route characteristics were determined for each of the origins and destinations associated with SNF shipments. Each origin represents a facility that generates or stores SNF that must be transported, and each destination represents a facility that stores SNF. For offsite transport, representative highway and rail routes were analyzed using the routing computer codes HIGHWAY (Johnson et al. 1993a) and INTERLINE (Johnson et al. 1993b). The routes were calculated conforming to current routing practices and applicable routing regulations and guidelines. Route characteristics include total shipment distance between each origin and destination and the fractions of travel in rural, suburban, and urban population density zones (see Table I-1). The HIGHWAY and INTERLINE routing computer codes are described below.

The HIGHWAY computer code predicts highway routes for transporting radioactive materials within the United States. The HIGHWAY database is a computerized road atlas that currently describes approximately 240,000 miles of roads. A complete description of the Interstate Highway System, United States highways, most of the principal state highways, and a number of local and community highways are identified in the database. The HIGHWAY computer code calculates routes that maximize the use of interstate highways. This feature allows the user to predict routes for transport of radioactive materials that conform to U.S. Department of Transportation regulations, as specified in 49 CFR Part 177, (CFR 1994a). The routes calculated conform to applicable guidelines and regulations; therefore, they represent routes that could be used. However, they may not be the actual routes used in the future. The code is updated periodically to reflect current road conditions, and it has been benchmarked against reported mileage and observations of commercial truck firms.

The INTERLINE computer code is designed to simulate routing of the United States rail system. The INTERLINE database consists of 94 separate subnetworks and represents various competing rail companies in the United States. The database used by INTERLINE was originally based on Federal Railroad Administration data and reflected the United States railroad system in 1974. The database has since been expanded and modified over the past two decades. The routes used for this study used the standard assumptions in the INTERLINE computer code that simulate the selection process railroads use to direct transport of radioactive material. Currently, there are no specific routing regulations for transporting radioactive material by rail. INTERLINE is updated periodically to reflect current track conditions, and it has been benchmarked against reported mileage and observations of commercial rail firms.

Table I-1. Transportation distances between facilities for spent nuclear fuel shipments.

Route		Miles	Rural (%)	Suburban (%)	Urban (%)
	Truck routes				
Idaho National Engineering Laboratory	Hanford Site	599.0	91.3	7.6	1.1
Idaho National Engineering Laboratory	Nevada Test Site	712.0	82.8	13.7	3.5
Idaho National Engineering Laboratory	Savannah River Site	2311.0	82.8	15.6	1.6
Idaho National Engineering Laboratory	Oak Ridge Reservation	2048.0	86.8	12.0	1.2

Idaho National Engineering Laboratory	Brookhaven National Laboratory	2437.0	81.7	15.9	2.5
Idaho National Engineering Laboratory	Argonne National Laboratory-East	1582.0	91.2	8.2	0.6
Idaho National Engineering Laboratory	Los Alamos National Laboratory	1144.0	88.7	9.8	1.4
Idaho National Engineering Laboratory	Sandia National Laboratories - Albuquerque	1168.0	88.6	9.8	1.6
Hanford Site	Nevada Test Site	1128.0	86.5	10.9	2.6
Hanford Site	Savannah River Site	2727.0	84.3	14.2	1.5
Hanford Site	Oak Ridge Reservation	2464.0	87.8	11.0	1.2
Hanford Site	Brookhaven National Laboratory	2853.0	83.3	14.5	2.3
Hanford Site	Argonne National Laboratory-East	1998.0	91.5	7.8	0.7
Hanford Site	Los Alamos National Laboratory	1560.0	89.8	8.8	1.3
Hanford Site	Sandia National Laboratories - Albuquerque	1584.0	89.7	8.8	1.4
Nevada Test Site	Savannah River Site	2414.0	83.1	15.1	1.8
Nevada Test Site	Oak Ridge Reservation	2151.0	86.9	11.5	1.6
Nevada Test Site	Brookhaven National Laboratory	2670.0	82.3	15.1	2.6
Nevada Test Site	Argonne National Laboratory-East	1815.0	91.0	8.0	1.0
Nevada Test Site	Los Alamos National Laboratory	997.0	93.2	5.7	1.1
Nevada Test Site	Sandia National Laboratories - Albuquerque	909.0	93.8	4.8	1.4
Savannah River Site	Oak Ridge Reservation	379.0	59.1	38.5	2.4
Savannah River Site	Brookhaven National Laboratory	897.0	58.4	36.6	4.9

Savannah River Site	Argonne National Laboratory-East	892.0	68.8	29.3	1.9
Savannah River Site	Los Alamos National Laboratory	1742.0	80.0	17.9	2.1
Savannah River Site	Sandia National Laboratories - Albuquerque	1644.0	80.1	17.8	2.1
Savannah River Site	Lawrence Livermore National Laboratory	2750.0	80.1	16.8	3.1
Oak Ridge Reservation	Brookhaven National Laboratory	821.0	56.9	37.9	5.2
Oak Ridge Reservation	Argonne National Laboratory-East	584.0	67.0	30.1	2.9
Oak Ridge Reservation	Los Alamos National Laboratory	1480.0	84.9	13.3	1.7
Oak Ridge Reservation	Sandia National Laboratories - Albuquerque	1382.0	85.4	12.9	1.7
Idaho National Engineering Laboratory	Hanford Site	658.0	91.4	7.1	1.4
Idaho National Engineering Laboratory	Nevada Test Site	756.0	92.8	5.9	1.3
Idaho National Engineering Laboratory	Savannah River Site	2407.0	82.8	15.2	2.0
Idaho National Engineering Laboratory	Oak Ridge Reservation	2055.0	90.7	7.8	1.5
Idaho National Engineering Laboratory	Brookhaven National Laboratory	2607.0	71.3	22.6	6.1
Idaho National Engineering Laboratory	Argonne National Laboratory-East	1655.0	93.4	6.0	0.6
Idaho National Engineering Laboratory	Los Alamos National Laboratory	1179.0	92.2	6.8	1.0
Idaho National Engineering Laboratory	Sandia National Laboratories - Albuquerque	1247.0	91.0	7.6	1.4
Hanford Site	Nevada Test Site	1302.0	93.0	5.9	1.1
Hanford Site	Savannah River Site	2953.0	84.7	13.5	1.8

Hanford Site	Oak Ridge Reservation	2601.0	91.2	7.4	1.3
Hanford Site	Brookhaven National Laboratory	3153.0	75.1	19.7	5.2
Hanford Site	Argonne National Laboratory-East	2200.0	93.3	6.0	0.7
Hanford Site	Los Alamos National Laboratory	1725.0	92.5	6.5	0.9
Hanford Site	Sandia National Laboratories - Albuquerque	1793.0	91.7	7.1	1.2
Nevada Test Site	Savannah River Site	2839.0	84.5	13.5	1.9
Nevada Test Site	Oak Ridge Reservation	2487.0	91.4	7.2	1.5
Nevada Test Site	Brookhaven National Laboratory	3039.0	74.6	20.0	5.4
Nevada Test Site	Argonne National Laboratory-East	2348.0	92.8	6.4	0.8
Nevada Test Site	Los Alamos National Laboratory	1169.0	92.8	5.9	1.3
Nevada Test Site	Sandia National Laboratories - Albuquerque	1065.0	94.6	4.5	0.9
Savannah River Site	Oak Ridge Reservation	417.0	68.8	29.8	1.4
Savannah River Site	Brookhaven National Laboratory	1239.0	48.0	37.4	14.5
Savannah River Site	Argonne National Laboratory-East	976.0	64.3	31.6	4.0
Savannah River Site	Los Alamos National Laboratory	2252.0	80.3	17.5	2.1
Savannah River Site	Sandia National Laboratories - Albuquerque	2315.0	79.9	18.1	2.1
Oak Ridge Reservation	Brookhaven National Laboratory	1152.0	39.5	44.7	15.8
Oak Ridge Reservation	Argonne National Laboratory-East	648.0	70.7	25.3	4.0
Oak Ridge Reservation	Los Alamos National Laboratory	1686.0	88.9	9.3	1.8
Oak Ridge Reservation	Sandia National Laboratories - Albuquerque	1749.0	87.9	10.3	1.8
Fort St. Vrain Nuclear	Savannah River Site	1636.0	78.9		

Generating Station				19.1	2.0
Fort St. Vrain Nuclear Generating Station	Hanford Site	1108.0	92.5	6.7	0.7
Fort St. Vrain Nuclear Generating Station	Idaho National Engineering Laboratory	692.0	92.3	7.1	0.5
Fort St. Vrain Nuclear Generating Station	Oak Ridge Reservation	1372.0	84.1	14.3	1.6
Fort St. Vrain Nuclear Generating Station	Nevada Test Site	852.0	90.2	7.9	1.9
Fort St. Vrain Nuclear Generating Station	Savannah River Site	1853.0	77.3	20.1	2.7
Fort St. Vrain Nuclear Generating Station	Hanford Site	1218.0	94.8	4.6	0.6
Fort St. Vrain Nuclear Generating Station	Idaho National Engineering Laboratory	672.0	96.0	3.5	0.4
Fort St. Vrain Nuclear Generating Station	Oak Ridge Reservation	1526.0	87.0	10.9	2.1
Fort St. Vrain Nuclear Generating Station	Nevada Test Site	1104.0	95.4	3.8	0.8
Savannah River Site	Hampton Roads, VA	505.0	71.2	27.0	1.9
Savannah River Site	Seattle-Tacoma, WA	2900.0	85.1	13.8	1.2
Savannah River Site	Charleston, SC	209.0	73.1	24.8	2.2
Savannah River Site	Savannah, GA	265.0	78.8	20.8	0.5
Savannah River Site	Oakland, CA	2791.0	79.5	17.0	3.5
Savannah River Site	Portland, OR	2849.0	84.4	14.0	1.6
Savannah River Site	Military Ocean Terminal, Sunny Point, NC	250.0	82.5	17.2	0.3
Savannah River Site	Alexandria Bay, NY	1012.0	66.8	32.4	0.8

Savannah River Site	Galveston, TX	1000.0	70.5	27	2.5
Hanford Site	Hampton Roads, VA	2903.0	85.0	13.3	1.7
Hanford Site	Seattle-Tacoma, WA	226.0	76.8	20.9	2.3
Hanford Site	Charleston, SC	2862.0	85.5	13.2	1.3
Hanford Site	Savannah, GA	2804.0	84.9	13.7	1.4
Hanford Site	Oakland, CA	875.0	78.1	17.8	4.1
Hanford Site	Portland, OR	236.0	86.0	10.7	3.4
Hanford Site	Military Ocean Terminal, Sunny Point, NC	2868.0	85.7	13.1	1.3
Hanford Site	Alexandria Bay, NY	2768.0	82.8	15.6	1.6
Hanford Site	Galveston, TX	2327.0	86.0	11.8	2.3
Idaho National Engineering Laboratory	Hampton Roads, VA	2487.0	83.7	14.5	1.8
Idaho National Engineering Laboratory	Seattle-Tacoma, WA	793.0	88.3	10.5	1.1
Idaho National Engineering Laboratory	Charleston, SC	2446.0	84.2	14.4	1.3
Idaho National Engineering Laboratory	Savannah, GA	2388.0	83.6	15.0	1.5
Idaho National Engineering Laboratory	Oakland, CA	963.0	84.5	11.0	4.4
Idaho National Engineering Laboratory	Portland, OR	721.0	90.2	8.1	1.6
Idaho National Engineering Laboratory	Military Ocean Terminal, Sunny Point, NC	2407.0	85.3	13.5	1.2
Idaho National Engineering Laboratory	Alexandria Bay, NY	2352.0	81.0	17.2	1.7
Idaho National Engineering	Galveston, TX	1911.0	84.5		

Laboratory				13.0	2.5
Oak Ridge Reservation	Hampton Roads, VA	548.0	70.3	27.3	2.3
Oak Ridge Reservation	Seattle-Tacoma, WA	2636.0	88.4	10.7	0.8
Oak Ridge Reservation	Charleston, SC	408.0	70.8	27.5	1.8
Oak Ridge Reservation	Savannah, GA	456.0	67.1	31.1	1.8
Oak Ridge Reservation	Oakland, CA	2563.0	86.3	10.7	3.0
Oak Ridge Reservation	Portland, OR	2585.0	87.7	11.0	1.3
Oak Ridge Reservation	Military Ocean Terminal, Sunny Point, NC	496.0	72.4	26.7	0.9
Oak Ridge Reservation	Alexandria Bay, NY	927.0	65.9	33.5	0.7
Oak Ridge Reservation	Galveston, TX	963.0	73.3	24.6	2.1
Nevada Test Site	Hampton Roads, VA	2590.0	83.9	14.0	2.1
Nevada Test Site	Seattle-Tacoma, WA	1322.0	85.5	12.1	2.4
Nevada Test Site	Charleston, SC	2549.0	84.5	14.0	1.6
Nevada Test Site	Savannah, GA	2492.0	83.8	14.4	1.7
Nevada Test Site	Oakland, CA	719.0	81.9	10.6	7.5
Nevada Test Site	Portland, OR	1250.0	86.4	10.8	2.8
Nevada Test Site	Military Ocean Terminal, Sunny Point, NC	2457.0	83.0	15.0	2.0
Nevada Test Site	Alexandria Bay, NY	2619.0	82.0	16.0	1.9
Nevada Test Site	Galveston, TX	1862.0	85.4	11.5	3.2
Savannah River Site	Hampton Roads, VA	529.0	74.3	24.1	1.6
Savannah River Site	Seattle-Tacoma, WA	3123.0	81.1		

				16.1	2.8
Savannah River Site	Charleston, SC	140.0	83.9	13.6	2.5
Savannah River Site	Savannah, GA	114.0	87.9	10.9	1.2
Savannah River Site	Oakland, CA	3192.0	79.2	16.7	4.1
Savannah River Site	Portland, OR	3154.0	82.0	15.4	2.6
Savannah River Site	Military Ocean Terminal, Sunny Point, NC	382.0	77.9	20.5	1.6
Savannah River Site	Alexandria Bay, NY	1281.0	53.8	35.5	10.7
Savannah River Site	Galveston, TX	1174.0	69.6	26.2	4.2
Hanford Site	Hampton Roads, VA	3187.0	83.8	13.6	2.7
Hanford Site	Seattle-Tacoma, WA	416.0	73.7	20.1	6.2
Hanford Site	Charleston, SC	3059.0	84.5	13.7	1.8
Hanford Site	Savannah, GA	3091.0	85.3	13.2	1.4
Hanford Site	Oakland, CA	986.0	78.5	15.8	5.7
Hanford Site	Portland, OR	239.0	82.1	13.4	4.5
Hanford Site	Military Ocean Terminal, Sunny Point, NC	3203.0	83.6	14.8	1.5
Hanford Site	Alexandria Bay, NY	2878.0	79.6	16.6	3.8
Hanford Site	Galveston, TX	2392.0	89.9	9.1	1.0
Idaho National Engineering Laboratory	Hampton Roads, VA	2641.0	81.8	15.2	3.0
Idaho National Engineering Laboratory	Seattle-Tacoma, WA	976.0	85.8	10.8	3.4
Idaho National Engineering Laboratory	Charleston, SC	2513.0	82.6	15.3	2.1

Idaho National Engineering Laboratory	Savannah, GA	2545.0	83.6	14.8	1.6
Idaho National Engineering Laboratory	Oakland, CA	1102.0	90.0	7.6	2.4
Idaho National Engineering Laboratory	Portland, OR	785.0	92.6	5.8	1.6
Idaho National Engineering Laboratory	Military Ocean Terminal, Sunny Point, NC	2657.0	81.6	16.7	1.7
Idaho National Engineering Laboratory	Alexandria Bay, NY	2332.0	76.4	19.1	4.5
Idaho National Engineering Laboratory	Galveston, TX	1846.0	88.9	10.1	1.0
Oak Ridge Reservation	Hampton Roads, VA	689.0	62.2	36.3	1.6
Oak Ridge Reservation	Seattle-Tacoma, WA	2795.0	84.6	12.8	2.6
Oak Ridge Reservation	Charleston, SC	581.0	65.2	33.3	1.5
Oak Ridge Reservation	Savannah, GA	587.0	66.2	32.1	1.7
Oak Ridge Reservation	Oakland, CA	2686.0	89.4	8.5	2.1
Oak Ridge Reservation	Portland, OR	2827.0	85.5	12.1	2.4
Oak Ridge Reservation	Military Ocean Terminal, Sunny Point, NC	542.0	61.5	37.1	1.5
Oak Ridge Reservation	Alexandria Bay, NY	972.0	57.5	35.7	6.8
Oak Ridge Reservation	Galveston, TX	1053.0	70.5	26.2	3.3
Nevada Test Site	Hampton Roads, VA	3073.0	83.6	13.6	2.8
Nevada Test Site	Seattle-Tacoma, WA	1620.0	89.3	8.4	2.3
Nevada Test Site	Charleston, SC	2945.0	84.3	13.7	2.0
Nevada Test Site	Savannah, GA	2977.0	85.2	13.2	1.5

Nevada Test Site	Oakland, CA	860.0	75.1	17.7	7.2
Nevada Test Site	Portland, OR	1429.0	93.5	5.3	1.2
Nevada Test Site	Military Ocean Terminal, Sunny Point, NC	3089.0	83.4	14.9	1.7
Nevada Test Site	Alexandria Bay, NC	2763.0	79.2	16.7	4.0
Nevada Test Site	Galveston, TX	1955.0	92.0	7.2	0.8
Savannah River Site	Cornell University	896.0	66.5	32.3	1.2
Savannah River Site	Georgia Institute of Technology	197.0	61.1	34.5	4.4
Savannah River Site	Idaho State University	2248.0	82.7	15.7	1.5
Savannah River Site	Iowa State University	1175.0	77.9	21.0	1.2
Savannah River Site	Kansas State University	1121.0	72.3	25.1	2.7
Savannah River Site	Manhattan College	830.0	62.1	35.2	2.7
Savannah River Site	Massachusetts Institute of Technology	1040.0	53.2	39.7	7.0
Savannah River Site	North Carolina State University	318.0	68.0	31.4	0.6
Savannah River Site	Ohio State University	708.0	69.6	29.6	0.7
Savannah River Site	Oregon State University	2937.0	83.7	14.6	1.7
Savannah River Site	Pennsylvania State University	849.0	69.6	29.5	0.9
Savannah River Site	Purdue University	768.0	70.0	29.2	0.8
Savannah River Site	Reed College	2849.0	84.4	14.0	1.6
Savannah River Site	Rensselaer Polytechnic Institute	955.0	64.3	34.5	1.2
Savannah River Site	Rhode Island Nuclear Science Center	1009.0	55.0	38.5	6.5

Savannah River Site	State University of New York - Buffalo	1001.0	68.8	29.8	1.5
Savannah River Site	Texas A&M University	1099.0	70.6	26.7	2.7
Savannah River Site	University of Arizona	1926.0	79.4	19.1	1.6
Savannah River Site	University of California - Irvine	2406.0	79.6	17.9	2.5
Savannah River Site	University of Florida	496.0	73.4	26.0	0.6
Savannah River Site	University of Illinois	803.0	73.9	24.6	1.5
Savannah River Site	University of Lowell	1045.0	53.1	40.2	6.8
Savannah River Site	University of Maryland	589.0	65.9	31.0	3.1
Savannah River Site	University of Michigan	903.0	62.7	34.8	2.5
Savannah River Site	University of Missouri - Columbia	858.0	70.6	27.0	2.3
Savannah River Site	University of Missouri - Rolla	835.0	71.2	26.9	1.9
Savannah River Site	University of New Mexico	1653.0	80.1	17.7	2.1
Savannah River Site	University of Texas	1169.0	71.4	26.6	1.9
Savannah River Site	University of Utah	2127.0	82.3	16.0	1.7
Savannah River Site	University of Virginia	478.0	73.1	25.9	1.0
Savannah River Site	University of Wisconsin	1038.0	67.9	29.4	2.8
Savannah River Site	Washington State University	2699.0	84.8	14.1	1.2
Savannah River Site	Worcester Polytechnic Institute	1002.0	54.2	38.8	7.1
Savannah River Site	Cornell University	1098.0	61.2	33.7	5.1
Savannah River Site	Georgia Institute of Technology	221.0	65.5	28.3	6.2

Savannah River Site	Idaho State University	2323.0	81.7	16.2	2.1
Savannah River Site	Iowa State University	1281.0	66.8	28.4	4.8
Savannah River Site	Kansas State University	1274.0	69.3	27.0	3.7
Savannah River Site	Manhattan College	1156.0	51.1	37.0	11.9
Savannah River Site	Massachusetts Institute of Technology	1223.0	50.6	36.6	12.8
Savannah River Site	North Carolina State University	385.0	78.6	20.1	1.3
Savannah River Site	Ohio State University	726.0	73.6	25.0	1.4
Savannah River Site	Oregon State University	3381.0	84.4	13.7	1.9
Savannah River Site	Pennsylvania State University	963.0	65.5	29.6	4.9
Savannah River Site	Purdue University	903.0	64.6	32.4	3.0
Savannah River Site	Reed College	3154.0	82.0	15.4	2.6
Savannah River Site	Rensselaer Polytechnic Institute	1044.0	52.3	34.9	12.8
Savannah River Site	Rhode Island Nuclear Science Center	1252.0	50.6	37.0	12.4
Savannah River Site	State University of New York - Buffalo	1051.0	65.1	30.8	4.1
Savannah River Site	Texas A&M University	1194.0	66.5	29.1	4.4
Savannah River Site	University of Arizona	2245.0	79.4	17.5	3.1
Savannah River Site	University of California - Irvine	3180.0	82.1	15.3	2.6
Savannah River Site	University of Florida	328.0	84.7	13.6	1.7
Savannah River Site	University of Illinois	1028.0	67.7	28.6	3.7
Savannah River Site	University of Lowell	1239.0	51.6	37.2	11.2
Savannah River Site	University of Maryland	669.0	67.8		

				27.6	4.6
Savannah River Site	University of Michigan	913.0	68.2	29.2	2.5
Savannah River Site	University of Missouri - Columbia	1011.0	66.6	29.5	4.0
Savannah River Site	University of Missouri - Rolla	966.0	65.3	30.7	4.0
Savannah River Site	University of New Mexico	2315.0	79.9	18.1	2.1
Savannah River Site	University of Texas	1314.0	71.8	23.6	4.6
Savannah River Site	University of Utah	2378.0	80.3	17.5	2.2
Savannah River Site	University of Virginia	637.0	75.1	22.8	2.2
Savannah River Site	University of Wisconsin	1092.0	62.7	32.0	5.3
Savannah River Site	Washington State University	2864.0	81.4	16.0	2.5
Savannah River Site	Worcester Polytechnic Institute	1176.0	52.1	35.8	12.1
Hanford Site	Cornell University	2730.0	82.7	15.4	1.9
Hanford Site	Georgia Institute of Technology	2550.0	85.6	13.0	1.4
Hanford Site	Idaho State University	546.0	90.2	8.1	1.7
Hanford Site	Iowa State University	1703.0	92.6	6.6	0.8
Hanford Site	Kansas State University	1624.0	92.8	6.5	0.7
Hanford Site	Manhattan College	2786.0	85.0	13.5	1.5
Hanford Site	Massachusetts Institute of Technology	2986.0	81.5	17.0	1.6
Hanford Site	North Carolina State University	2862.0	83.2	15.5	1.3
Hanford Site	Ohio State University	2342.0	88.3	10.6	1.1
Hanford Site	Oregon State University	324.0	79.5	16.3	4.2

Hanford Site	Pennsylvania State University	2578.0	86.2	12.7	1.1
Hanford Site	Purdue University	2111.0	90.0	8.9	1.1
Hanford Site	Reed College	236.0	86.0	10.7	3.4
Hanford Site	Rensselaer Polytechnic Institute	2819.0	82.0	16.1	1.9
Hanford Site	Rhode Island Nuclear Science Center	2965.0	81.2	15.9	2.9
Hanford Site	State University of New York - Buffalo	2534.0	84.8	13.4	1.8
Hanford Site	Texas A&M University	2212.0	88.7	9.7	1.6
Hanford Site	University of Arizona	1699.0	80.2	14.7	5.0
Hanford Site	University of California - Irvine	1270.0	79.3	14.5	6.2
Hanford Site	University of Florida	2894.0	84.1	14.6	1.4
Hanford Site	University of Illinois	2033.0	91.2	8.0	0.8
Hanford Site	University of Lowell	2991.0	81.4	17.1	1.5
Hanford Site	University of Maryland	2753.0	84.7	13.8	1.5
Hanford Site	University of Michigan	2227.0	87.0	11.8	1.2
Hanford Site	University of Missouri - Columbia	1870.0	90.6	8.3	1.1
Hanford Site	University of Missouri - Rolla	2082.0	88.4	10.2	1.4
Hanford Site	University of New Mexico	1593.0	89.7	8.8	1.5
Hanford Site	University of Texas	2216.0	87.0	11.5	1.5
Hanford Site	University of Utah	643.0	87.5	10.6	1.9
Hanford Site	University of Virginia	2757.0	86.1	12.4	1.5

Hanford Site	University of Wisconsin	1943.0	88.2	10.8	1.0
Hanford Site	Washington State University	361.0	87.3	11.6	1.1
Hanford Site	Worcester Polytechnic Institute	2948.0	82.2	16.3	1.5
Hanford Site	Cornell University	2842.0	81.0	15.4	3.6
Hanford Site	Georgia Institute of Technology	2732.0	86.3	12.3	1.4
Hanford Site	Idaho State University	602.0	92.2	6.6	1.2
Hanford Site	Iowa State University	1788.0	93.7	5.6	0.7
Hanford Site	Kansas State University	1743.0	95.4	4.1	0.6
Hanford Site	Manhattan College	3070.0	77.0	19.1	3.9
Hanford Site	Massachusetts Institute of Technology	3105.0	77.5	18.7	3.8
Hanford Site	North Carolina State University	3172.0	83.8	14.6	1.7
Hanford Site	Ohio State University	2482.0	86.1	11.0	2.9
Hanford Site	Oregon State University	340.0	70.6	22.2	7.2
Hanford Site	Pennsylvania State University	2760.0	79.3	16.7	4.0
Hanford Site	Purdue University	2359.0	90.8	8.0	1.1
Hanford Site	Reed College	239.0	82.1	13.4	4.5
Hanford Site	Rensselaer Polytechnic Institute	2934.0	78.6	17.3	4.0
Hanford Site	Rhode Island Nuclear Science Center	3166.0	76.0	19.6	4.4
Hanford Site	State University of New York - Buffalo	2637.0	81.7	14.6	3.7
Hanford Site	Texas A&M University	2954.0	85.2	11.2	3.7

Hanford Site	University of Arizona	1804.0	80.2	14.5	5.4
Hanford Site	University of California - Irvine	1528.0	88.2	8.6	3.2
Hanford Site	University of Florida	3138.0	85.5	13.0	1.5
Hanford Site	University of Illinois	2158.0	93.0	6.0	1.0
Hanford Site	University of Lowell	3095.0	77.6	18.6	3.9
Hanford Site	University of Maryland	2900.0	82.6	13.7	3.8
Hanford Site	University of Michigan	2369.0	85.7	11.4	2.9
Hanford Site	University of Missouri - Columbia	1948.0	94.1	5.3	0.6
Hanford Site	University of Missouri - Rolla	2246.0	89.1	9.3	1.6
Hanford Site	University of New Mexico	1796.0	91.5	7.2	1.2
Hanford Site	University of Texas	2473.0	89.8	8.9	1.3
Hanford Site	University of Utah	774.0	89.6	8.8	1.7
Hanford Site	University of Virginia	2902.0	83.9	13.4	2.7
Hanford Site	University of Wisconsin	2210.0	88.9	9.2	1.9
Hanford Site	Washington State University	251.0	86.0	9.4	4.5
Hanford Site	Worcester Polytechnic Institute	3089.0	77.2	18.7	4.1
Idaho National Engineering Laboratory	Cornell University	2314.0	80.9	17.1	2.1
Idaho National Engineering Laboratory	Georgia Institute of Technology	2134.0	84.2	14.4	1.4
Idaho National Engineering Laboratory	Idaho State University	65.0	83.7	12.5	3.9
Idaho National Engineering	Iowa State University	1287.0	92.5	6.8	0.7

Laboratory

Idaho National Engineering Laboratory	Kansas State University	1208.0	92.8	6.7	0.5
Idaho National Engineering Laboratory	Manhattan College	2370.0	83.6	14.8	1.6
Idaho National Engineering Laboratory	Massachusetts Institute of Technology	2570.0	79.6	18.7	1.6
Idaho National Engineering Laboratory	North Carolina State University	2446.0	81.5	17.2	1.3
Idaho National Engineering Laboratory	Ohio State University	1926.0	87.3	11.6	1.1
Idaho National Engineering Laboratory	Oregon State University	809.0	87.2	10.7	2.2
Idaho National Engineering Laboratory	Pennsylvania State University	2162.0	84.9	14.0	1.1
Idaho National Engineering Laboratory	Purdue University	1695.0	89.3	9.6	1.1
Idaho National Engineering Laboratory	Reed College	721.0	90.2	8.1	1.6
Idaho National Engineering Laboratory	Rensselaer Polytechnic Institute	2403.0	80.1	17.9	2.0
Idaho National Engineering Laboratory	Rhode Island Nuclear Science Center	2549.0	79.3	17.5	3.2
Idaho National Engineering Laboratory	State University of New York - Buffalo	2118.0	83.2	14.8	2.0
Idaho National Engineering Laboratory	Texas A&M University	1796.0	87.7	10.5	1.7
Idaho National Engineering Laboratory	University of Arizona	1301.0	83.8	12.9	3.3
Idaho National Engineering Laboratory	University of California - Irvine	942.0	79.8	13.8	6.4
Idaho National Engineering Laboratory	University of Florida	2478.0	82.6	16.0	1.4

Idaho National Engineering Laboratory	University of Illinois	1617.0	90.8	8.5	0.7
Idaho National Engineering Laboratory	University of Lowell	2575.0	79.5	18.9	1.5
Idaho National Engineering Laboratory	University of Maryland	2337.0	83.3	15.2	1.6
Idaho National Engineering Laboratory	University of Michigan	1811.0	85.6	13.2	1.2
Idaho National Engineering Laboratory	University of Missouri - Columbia	1454.0	90.0	8.9	1.1
Idaho National Engineering Laboratory	University of Missouri - Rolla	1666.0	87.3	11.3	1.5
Idaho National Engineering Laboratory	University of New Mexico	1177.0	88.6	9.8	1.6
Idaho National Engineering Laboratory	University of Texas	1800.0	85.7	12.7	1.6
Idaho National Engineering Laboratory	University of Utah	227.0	77.7	18.9	3.4
Idaho National Engineering Laboratory	University of Virginia	2341.0	85.0	13.5	1.5
Idaho National Engineering Laboratory	University of Wisconsin	1612.0	89.8	9.2	1.0
Idaho National Engineering Laboratory	Washington State University	652.0	91.9	7.3	0.8
Idaho National Engineering Laboratory	Worcester Polytechnic Institute	2532.0	80.4	18.0	1.6
Idaho National Engineering Laboratory	Cornell University	2296.0	78.1	17.6	4.2
Idaho National Engineering Laboratory	Georgia Institute of Technology	2186.0	84.5	13.9	1.6
Idaho National Engineering Laboratory	Idaho State University	56.0	82.5	13.2	4.3

Idaho National Engineering Laboratory	Iowa State University	1242.0	93.9	5.4	0.7
Idaho National Engineering Laboratory	Kansas State University	1197.0	96.3	3.2	0.4
Idaho National Engineering Laboratory	Manhattan College	2524.0	73.5	21.9	4.6
Idaho National Engineering Laboratory	Massachusetts Institute of Technology	2559.0	74.1	21.5	4.4
Idaho National Engineering Laboratory	North Carolina State University	2626.0	81.8	16.4	1.8
Idaho National Engineering Laboratory	Ohio State University	1936.0	84.1	12.5	3.4
Idaho National Engineering Laboratory	Oregon State University	878.0	87.2	9.7	3.1
Idaho National Engineering Laboratory	Pennsylvania State University	2214.0	75.9	19.4	4.7
Idaho National Engineering Laboratory	Purdue University	1813.0	90.1	8.7	1.2
Idaho National Engineering Laboratory	Reed College	785.0	92.6	5.8	1.6
Idaho National Engineering Laboratory	Rensselaer Polytechnic Institute	2388.0	75.3	19.9	4.8
Idaho National Engineering Laboratory	Rhode Island Nuclear Science Center	2620.0	72.4	22.5	5.1
Idaho National Engineering Laboratory	State University of New York - Buffalo	2091.0	78.7	16.9	4.4
Idaho National Engineering Laboratory	Texas A&M University	1920.0	89.6	9.4	1.0
Idaho National Engineering Laboratory	University of Arizona	1376.0	90.8	7.3	1.9
Idaho National Engineering Laboratory	University of California - Irvine	982.0	85.4	10.0	4.5

Idaho National Engineering Laboratory	University of Florida	2592.0	83.8	14.6	1.6
Idaho National Engineering Laboratory	University of Illinois	1612.0	92.9	6.0	1.1
Idaho National Engineering Laboratory	University of Lowell	2549.0	74.2	21.3	4.5
Idaho National Engineering Laboratory	University of Maryland	2354.0	80.1	15.5	4.4
Idaho National Engineering Laboratory	University of Michigan	1823.0	83.4	13.0	3.6
Idaho National Engineering Laboratory	University of Missouri - Columbia	1402.0	94.4	5.1	0.5
Idaho National Engineering Laboratory	University of Missouri - Rolla	1619.0	92.6	6.1	1.3
Idaho National Engineering Laboratory	University of New Mexico	1250.0	90.8	7.8	1.4
Idaho National Engineering Laboratory	University of Texas	1927.0	88.8	9.8	1.4
Idaho National Engineering Laboratory	University of Utah	228.0	80.7	15.6	3.7
Idaho National Engineering Laboratory	University of Virginia	2357.0	81.8	15.1	3.1
Idaho National Engineering Laboratory	University of Wisconsin	1664.0	87.5	10.3	2.2
Idaho National Engineering Laboratory	Washington State University	876.0	92.2	6.2	1.6
Idaho National Engineering Laboratory	Worcester Polytechnic Institute	2544.0	73.8	21.5	4.7
Oak Ridge Reservation	Cornell University	821.0	65.7	33.2	1.1
Oak Ridge Reservation	Georgia Institute of Technology	202.0	53.2	45.1	1.8
Oak Ridge Reservation	Idaho State University	1985.0	86.8	12.0	1.2

Oak Ridge Reservation	Iowa State University	900.0	75.2	23.4	1.5
Oak Ridge Reservation	Kansas State University	857.0	78.6	19.2	2.2
Oak Ridge Reservation	Manhattan College	754.0	60.9	36.4	2.7
Oak Ridge Reservation	Massachusetts Institute of Technology	965.0	51.6	41.1	7.4
Oak Ridge Reservation	North Carolina State University	408.0	54.5	43.7	1.8
Oak Ridge Reservation	Ohio State University	400.0	67.7	31.1	1.2
Oak Ridge Reservation	Oregon State University	2674.0	86.8	11.7	1.5
Oak Ridge Reservation	Pennsylvania State University	774.0	69.1	30.1	0.8
Oak Ridge Reservation	Purdue University	460.0	68.6	30.2	1.3
Oak Ridge Reservation	Reed College	2585.0	87.7	11.0	1.3
Oak Ridge Reservation	Rensselaer Polytechnic Institute	879.0	63.4	35.5	1.1
Oak Ridge Reservation	Rhode Island Nuclear Science Center	933.0	53.4	39.8	6.8
Oak Ridge Reservation	State University of New York - Buffalo	744.0	61.9	35.6	2.5
Oak Ridge Reservation	Texas A&M University	1004.0	81.5	17.2	1.3
Oak Ridge Reservation	University of Arizona	1782.0	83.2	15.1	1.7
Oak Ridge Reservation	University of California - Irvine	2209.0	86.0	10.9	3.0
Oak Ridge Reservation	University of Florida	546.0	65.4	33.1	1.5
Oak Ridge Reservation	University of Illinois	516.0	68.0	29.9	2.2
Oak Ridge Reservation	University of Lowell	970.0	51.4	41.5	7.1
Oak Ridge Reservation	University of Maryland	537.0	70.2	27.2	2.6

Oak Ridge Reservation	University of Michigan	595.0	57.8	38.5	3.7
Oak Ridge Reservation	University of Missouri - Columbia	594.0	79.0	19.5	1.5
Oak Ridge Reservation	University of Missouri - Rolla	571.0	80.2	19.0	0.9
Oak Ridge Reservation	University of New Mexico	1391.0	85.4	12.9	1.7
Oak Ridge Reservation	University of Texas	1026.0	76.9	20.9	2.2
Oak Ridge Reservation	University of Utah	1864.0	86.6	12.1	1.3
Oak Ridge Reservation	University of Virginia	402.0	72.8	26.4	0.8
Oak Ridge Reservation	University of Wisconsin	730.0	66.1	30.0	3.9
Oak Ridge Reservation	Washington State University	2435.0	88.3	10.8	0.9
Oak Ridge Reservation	Worcester Polytechnic Institute	927.0	52.5	40.0	7.5
Oak Ridge Reservation	Cornell University	935.0	60.9	32.8	6.3
Oak Ridge Reservation	Georgia Institute of Technology	228.0	47.1	50.9	2.0
Oak Ridge Reservation	Idaho State University	1996.0	89.9	8.5	1.6
Oak Ridge Reservation	Iowa State University	954.0	71.7	22.0	6.3
Oak Ridge Reservation	Kansas State University	948.0	82.2	14.7	3.1
Oak Ridge Reservation	Manhattan College	1164.0	54.3	39.1	6.6
Oak Ridge Reservation	Massachusetts Institute of Technology	1199.0	56.1	37.7	6.2
Oak Ridge Reservation	North Carolina State University	511.0	60.9	36.9	2.2
Oak Ridge Reservation	Ohio State University	406.0	66.9	27.8	5.3
Oak Ridge Reservation	Oregon State University	3055.0	90.0	8.4	1.6
Oak Ridge Reservation	Pennsylvania State University	822.0	55.2		

				37.4	7.3
Oak Ridge Reservation	Purdue University	495.0	74.4	22.6	3.0
Oak Ridge Reservation	Reed College	2827.0	85.5	12.1	2.4
Oak Ridge Reservation	Rensselaer Polytechnic Institute	1028.0	55.9	36.8	7.3
Oak Ridge Reservation	Rhode Island Nuclear Science Center	1259.0	53.5	39.0	7.5
Oak Ridge Reservation	State University of New York - Buffalo	731.0	57.7	34.9	7.4
Oak Ridge Reservation	Texas A&M University	1013.0	80.0	18.6	1.5
Oak Ridge Reservation	University of Arizona	2103.0	85.1	12.9	2.0
Oak Ridge Reservation	University of California - Irvine	2615.0	88.0	9.5	2.5
Oak Ridge Reservation	University of Florida	634.0	68.2	29.9	1.9
Oak Ridge Reservation	University of Illinois	592.0	75.4	21.3	3.3
Oak Ridge Reservation	University of Lowell	1189.0	56.2	37.4	6.4
Oak Ridge Reservation	University of Maryland	582.0	53.9	40.4	5.6
Oak Ridge Reservation	University of Michigan	591.0	63.3	30.1	6.6
Oak Ridge Reservation	University of Missouri - Columbia	695.0	82.5	14.2	3.3
Oak Ridge Reservation	University of Missouri - Rolla	640.0	82.3	14.4	3.3
Oak Ridge Reservation	University of New Mexico	1749.0	87.9	10.3	1.8
Oak Ridge Reservation	University of Texas	1045.0	75.7	22.1	2.1
Oak Ridge Reservation	University of Utah	2051.0	88.0	10.3	1.7
Oak Ridge Reservation	University of Virginia	451.0	53.6	44.1	2.3
Oak Ridge Reservation	University of Wisconsin	765.0	67.1	25.5	7.4

Oak Ridge Reservation	Washington State University	2536.0	85.3	12.4	2.3
Oak Ridge Reservation	Worcester Polytechnic Institute	1183.0	55.2	37.9	6.9
Nevada Test Site	Cornell University	2547.0	81.7	16.1	2.2
Nevada Test Site	Georgia Institute of Technology	2238.0	84.4	13.8	1.7
Nevada Test Site	Idaho State University	649.0	82.5	13.8	3.6
Nevada Test Site	Iowa State University	1520.0	92.0	6.8	1.2
Nevada Test Site	Kansas State University	1312.0	92.5	6.4	1.1
Nevada Test Site	Manhattan College	2603.0	84.1	14.0	1.8
Nevada Test Site	Massachusetts Institute of Technology	2802.0	80.5	17.7	1.8
Nevada Test Site	North Carolina State University	2549.0	81.9	16.5	1.6
Nevada Test Site	Ohio State University	2098.0	85.8	12.3	2.0
Nevada Test Site	Oregon State University	1245.0	81.8	13.5	4.7
Nevada Test Site	Pennsylvania State University	2395.0	85.3	13.3	1.4
Nevada Test Site	Purdue University	1928.0	89.3	9.2	1.5
Nevada Test Site	Reed College	1250.0	86.4	10.8	2.8
Nevada Test Site	Rensselaer Polytechnic Institute	2636.0	81.0	16.9	2.2
Nevada Test Site	Rhode Island Nuclear Science Center	2782.0	80.1	16.6	3.2
Nevada Test Site	State University of New York - Buffalo	2350.0	83.8	14.0	2.2
Nevada Test Site	Texas A&M University	1852.0	85.6	11.9	2.5
Nevada Test Site	University of Arizona	723.0	85.0	11.1	3.9

Nevada Test Site	University of California - Irvine	364.0	76.1	11.6	12.4
Nevada Test Site	University of Florida	2582.0	82.9	15.4	1.7
Nevada Test Site	University of Illinois	1850.0	90.6	8.3	1.1
Nevada Test Site	University of Lowell	2808.0	80.3	17.9	1.8
Nevada Test Site	University of Maryland	2509.0	82.3	15.5	2.2
Nevada Test Site	University of Michigan	2044.0	86.1	12.4	1.5
Nevada Test Site	University of Missouri - Columbia	1557.0	89.9	8.5	1.6
Nevada Test Site	University of Missouri - Rolla	1769.0	87.4	10.7	1.8
Nevada Test Site	University of New Mexico	918.0	93.8	4.8	1.5
Nevada Test Site	University of Texas	1662.0	86.5	10.5	3.0
Nevada Test Site	University of Utah	487.0	85.0	11.4	3.6
Nevada Test Site	University of Virginia	2444.0	85.2	13.0	1.8
Nevada Test Site	University of Wisconsin	1857.0	90.5	8.2	1.3
Nevada Test Site	Washington State University	1286.0	86.6	11.1	2.4
Nevada Test Site	Worcester Polytechnic Institute	2765.0	81.2	17.0	1.8
Nevada Test Site	Cornell University	2727.0	80.7	15.5	3.8
Nevada Test Site	Georgia Institute of Technology	2618.0	86.1	12.3	1.6
Nevada Test Site	Idaho State University	700.0	93.6	5.4	1.0
Nevada Test Site	Iowa State University	1674.0	94.0	5.1	0.9
Nevada Test Site	Kansas State University	1628.0	95.8	3.5	0.7

Nevada Test Site	Manhattan College	2956.0	76.6	19.3	4.1
Nevada Test Site	Massachusetts Institute of Technology	2990.0	77.0	19.0	4.0
Nevada Test Site	North Carolina State University	3058.0	83.6	14.7	1.8
Nevada Test Site	Ohio State University	2367.0	86.0	11.0	3.1
Nevada Test Site	Oregon State University	1400.0	79.8	14.7	5.4
Nevada Test Site	Pennsylvania State University	2646.0	78.9	16.9	4.2
Nevada Test Site	Purdue University	2245.0	90.9	7.8	1.3
Nevada Test Site	Reed College	1429.0	93.5	5.3	1.2
Nevada Test Site	Rensselaer Polytechnic Institute	2820.0	78.2	17.5	4.3
Nevada Test Site	Rhode Island Nuclear Science Center	3051.0	75.6	19.9	4.6
Nevada Test Site	State University of New York - Buffalo	2522.0	81.4	14.7	3.9
Nevada Test Site	Texas A&M University	1967.0	92.0	6.6	1.4
Nevada Test Site	University of Arizona	818.0	90.6	7.4	2.0
Nevada Test Site	University of California -Irvine	424.0	78.0	13.8	8.2
Nevada Test Site	University of Florida	3024.0	85.3	13.1	1.6
Nevada Test Site	University of Illinois	2044.0	93.2	5.6	1.2
Nevada Test Site	University of Lowell	2980.0	77.2	18.8	4.1
Nevada Test Site	University of Maryland	2786.0	82.3	13.7	4.0
Nevada Test Site	University of Michigan	2255.0	85.5	11.3	3.2
Nevada Test Site	University of Missouri - Columbia	1833.0	94.4	4.8	0.7
Nevada Test Site	University of Missouri - Rolla	2050.0	93.0	5.7	

1.4

Nevada Test Site	University of New Mexico	1065.0	94.6	4.5	0.9
Nevada Test Site	University of Texas	2358.0	89.9	8.7	1.4
Nevada Test Site	University of Utah	528.0	98.0	1.8	0.2
Nevada Test Site	University of Virginia	2788.0	83.7	13.4	2.9
Nevada Test Site	University of Wisconsin	2096.0	88.9	9.0	2.1
Nevada Test Site	Washington State University	1520.0	93.2	5.6	1.2
Nevada Test Site	Worcester Polytechnic Institute	2975.0	76.8	18.9	4.3
West Valley Demonstration Plant	Savannah River Site	883.0	70.3	28.5	1.2
West Valley Demonstration Plant	Hanford Site	2556.0	84.6	13.7	1.7
West Valley Demonstration Plant	Idaho National Engineering Laboratory	2140.0	83.0	15.2	1.8
West Valley Demonstration Plant	Oak Ridge Reservation	766.0	62.2	36.0	1.8
West Valley Demonstration Plant	Nevada Test Site	2373.0	83.7	14.3	2.0
Babcock & Wilcox	Savannah River Site	455.0	71.0	28.2	0.9
Babcock & Wilcox	Hanford Site	2738.0	85.9	12.7	1.4
Babcock & Wilcox	Idaho National Engineering Laboratory	2322.0	84.7	13.8	1.5
Babcock & Wilcox	Oak Ridge Reservation	350.0	65.4	33.8	0.8
Babcock & Wilcox	Nevada Test Site	2491.0	84.0	14.5	1.5
West Valley Demonstration Plant	Savannah River Site	1217.0	62.8	32.4	4.9

West Valley Demonstration Plant	Hanford Site	2654.0	78.3	18.0	3.7
West Valley Demonstration Plant	Idaho National Engineering Laboratory	2108.0	74.9	20.5	4.7
West Valley Demonstration Plant	Oak Ridge Reservation	889.0	64.5	30.1	5.5
West Valley Demonstration Plant	Nevada Test Site	2554.0	80.8	15.1	4.0
Babcock & Wilcox	Savannah River Site	661.0	76.8	21.5	1.6
Babcock & Wilcox	Hanford Site	2879.0	84.2	13.1	2.7
Babcock & Wilcox	Idaho National Engineering Laboratory	2333.0	82.1	14.8	3.2
Babcock & Wilcox	Oak Ridge Reservation	386.0	48.0	49.6	2.4
Babcock & Wilcox	Nevada Test Site	2765.0	84.0	13.1	2.9
Three Mile Island	Idaho National Engineering Laboratory	2315.0	75.8	19.6	4.6
Pleasanton, CA	Idaho National Engineering Laboratory	969.0	84.0	12.2	3.8
Pleasanton, CA	Hanford Site	881.0	77.5	19.1	3.4
Pleasanton, CA	Savannah River Site	2768.0	80.1	16.8	3.1
Pleasanton, CA	Oak Ridge Reservation	2532.0	87.0	10.5	2.5
Pleasanton, CA	Nevada Test Site	687.0	84.3	9.6	6.1
Gaithersburg, MD	Idaho National Engineering Laboratory	2316.0	83.9	14.9	1.2
Gaithersburg, MD	Hanford Site	2732.0	85.3	13.5	1.2
Gaithersburg, MD	Savannah River Site	597.0	66.8	30.7	2.5
Gaithersburg, MD	Oak Ridge Reservation	536.0	70.6	27.4	2.0
Gaithersburg, MD	Nevada Test Site	2488.0	82.9		

				15.2	1.9
San Ramon, CA	Idaho National Engineering Laboratory	962.0	84.4	12.0	3.6
San Ramon, CA	Hanford Site	874.0	77.9	18.9	3.2
San Ramon, CA	Savannah River Site	2775.0	80.0	16.9	3.1
San Ramon, CA	Oak Ridge Reservation	2538.0	86.8	10.5	2.6
San Ramon, CA	Nevada Test Site	694.0	83.7	9.9	6.3
Midland, MI	Idaho National Engineering Laboratory	1902.0	82.9	15.8	1.3
Midland, MI	Hanford Site	2318.0	84.7	14.0	1.3
Midland, MI	Savannah River Site	1036.0	58.9	37.9	3.2
Midland, MI	Oak Ridge Reservation	719.0	52.7	42.7	4.6
Midland, MI	Nevada Test Site	2135.0	83.6	14.8	1.6
San Diego, CA	Idaho National Engineering Laboratory	976.0	78.8	17.1	4.1
San Diego, CA	Hanford Site	1352.0	76.3	16.0	7.7
San Diego, CA	Savannah River Site	2345.0	81.0	17.0	2.0
San Diego, CA	Oak Ridge Reservation	2193.0	84.1	13.8	2.1
San Diego, CA	Nevada Test Site	398.0	73.9	19.8	6.3
Denver, CO	Idaho National Engineering Laboratory	717.0	91.2	7.9	0.9
Denver, CO	Hanford Site	1133.0	91.8	7.2	1.0
Denver, CO	Savannah River Site	1613.0	79.2	18.9	1.9
Denver, CO	Oak Ridge Reservation	1340.0	84.5	14.1	1.5
Denver, CO	Nevada Test Site	819.0	90.7	7.5	1.8

McClellan AFB, CA	Idaho National Engineering Laboratory	875.0	88.6	8.8	2.6
McClellan AFB, CA	Hanford Site	830.0	80.5	17.0	2.6
McClellan AFB, CA	Savannah River Site	2780.0	84.4	13.7	1.9
McClellan AFB, CA	Oak Ridge Reservation	2517.0	87.8	10.5	1.6
McClellan AFB, CA	Nevada Test Site	735.0	81.1	11.2	7.6
Pleasanton, CA	Idaho National Engineering Laboratory	965.0	85.6	10.4	4.0
Pleasanton, CA	Hanford Site	1002.0	77.5	16.0	6.4
Pleasanton, CA	Savannah River Site	3170.0	79.6	16.5	3.8
Pleasanton, CA	Oak Ridge Reservation	3029.0	83.5	13.4	3.1
Pleasanton, CA	Nevada Test Site	838.0	76.2	17.4	6.3
Gaithersburg, MD	Idaho National Engineering Laboratory	2335.0	80.5	15.4	4.0
Gaithersburg, MD	Hanford Site	2881.0	83.0	13.6	3.4
Gaithersburg, MD	Savannah River Site	659.0	68.4	27.7	3.8
Gaithersburg, MD	Oak Ridge Reservation	819.0	59.4	37.3	3.3
Gaithersburg, MD	Nevada Test Site	2767.0	82.7	13.7	3.6
San Ramon, CA	Idaho National Engineering Laboratory	965.0	85.6	10.4	4.0
San Ramon, CA	Hanford Site	1002.0	77.5	16.0	6.4
San Ramon, CA	Savannah River Site	3170.0	79.6	16.6	3.8
San Ramon, CA	Oak Ridge Reservation	3029.0	83.5	13.4	3.1
San Ramon, CA	Nevada Test Site	838.0	76.2	17.4	6.3

Midland, MI	Idaho National Engineering Laboratory	1961.0	82.3	14.2	3.5
Midland, MI	Hanford Site	2507.0	84.7	12.4	2.9
Midland, MI	Savannah River Site	996.0	65.9	31.2	2.9
Midland, MI	Oak Ridge Reservation	645.0	58.4	37.3	4.3
Midland, MI	Nevada Test Site	2392.0	84.5	12.4	3.1
San Diego, CA	Idaho National Engineering Laboratory	1076.0	82.6	11.4	6.0
San Diego, CA	Hanford Site	1622.0	86.2	9.5	4.3
San Diego, CA	Savannah River Site	3274.0	81.3	15.6	3.1
San Diego, CA	Oak Ridge Reservation	2709.0	86.8	10.0	3.1
San Diego, CA	Nevada Test Site	518.0	73.4	15.9	10.7
Denver, CO	Idaho National Engineering Laboratory	708.0	94.7	4.6	0.6
Denver, CO	Hanford Site	1254.0	94.1	5.2	0.7
Denver, CO	Savannah River Site	2125.0	77.0	20.5	2.6
Denver, CO	Oak Ridge Reservation	1560.0	85.0	12.6	2.3
Denver, CO	Nevada Test Site	1140.0	94.6	4.4	0.9
McClellan AFB, CA	Idaho National Engineering Laboratory	853.0	90.3	7.8	1.9
McClellan AFB, CA	Hanford Site	890.0	81.0	14.3	4.7
McClellan AFB, CA	Savannah River Site	3160.0	79.4	16.7	3.9
McClellan AFB, CA	Oak Ridge Reservation	2747.0	87.8	10.2	2.0
McClellan AFB, CA	Nevada Test Site	827.0	75.4	17.7	6.9

I-3.2 Spent Nuclear Fuel Shipments

In the transportation analyses, SNF was divided into a number of categories: (a) commercial, (b) DOE research, (c) foreign research reactor, (d) graphite, (e) N Reactor, (f) naval-type, (g) Savannah River Site production reactor, and (h) university research reactor. More details on these fuel types may be found in Appendix J of Volume 1 of this EIS. The estimated number of SNF shipments are presented by fuel type, origin-destination pair, and transport mode for each alternative in Tables I-2 and I-3 (Heiselmann 1995). Each shipment, whether by truck or rail, was assumed to consist of one shipping container. However, the size of shipping container was variable, depending on the type of SNF and the transport mode (truck or rail). At this time, insufficient data exist to determine the transport mode for all shipments. Therefore, the number of truck or rail shipments was based on either 100 percent transport by truck or 100 percent transport by rail to bound potential impacts.

The shipments in this appendix include offsite transport of naval-type SNF stored at the Idaho Chemical Processing Plant as of June 1995 to storage locations at other sites as identified in the alternatives. Transport of naval SNF from shipyards and prototypes to the equivalent Expended Core Facility at the alternative sites are addressed in Appendix D of Volume 1 of this EIS, along with transport of naval test specimens.

This appendix also includes transport of foreign research reactor SNF from the six points of entry identified in the Implementation Plan for this EIS (Hampton Roads, Virginia; Charleston, South Carolina; Savannah, Georgia; Seattle-Tacoma, Washington; Portland, Oregon; and Oakland, California) to sites as identified in the alternatives. Impacts of shipments to the Military Ocean Terminal at Sunny Point, North Carolina, were analyzed because this terminal was recently used for foreign research reactor SNF shipments. Impacts of shipments to Galveston, Texas, were analyzed because this point of entry is on the Gulf Coast and has container-handling experience. The ocean-going portion of foreign research reactor SNF shipments and a detailed evaluation of point of entry activities are not assessed in this EIS, but will be assessed in the Environmental Impact Statement on a Proposed Nuclear Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel.

The No Action alternative considers only transport of naval SNF and test specimens. These shipments are addressed in Appendix D of Volume 1 of this EIS. For the Decentralization alternative, university research reactor, foreign research reactor, and non-DOE research reactor SNF would be transported to the Idaho National Engineering Laboratory or the Savannah River Site.

For the 1992/1993 Planning Basis alternative, commercial, DOE research, and graphite SNF would be transported to the Idaho National Engineering Laboratory or the Savannah River Site. University research reactor, foreign research reactor, and non-DOE research reactor SNF would also continue to be transported to the Idaho National Engineering Laboratory or the Savannah River Site.

For the Regionalization alternatives, SNF would be consolidated based on fuel type or geography. More shipments of SNF would occur than for the 1992/1993 Planning Basis alternative and all types of SNF would be transported. For the Regionalization by Fuel Type alternative, N-Reactor SNF, naval-type SNF, and Savannah River Site production reactor SNF and targets would not be transported. Generally, aluminum SNF would be transported to the Savannah River Site and stainless steel SNF would be transported to the Idaho National Engineering Laboratory. For the Regionalization by Geography alternative, SNF from west of the Mississippi River would be transported to the Hanford Site, the

Idaho National Engineering Laboratory, or the Nevada Test Site. SNF from east of the Mississippi River would be transported to the Savannah River Site or the Oak Ridge Reservation.

For the Centralization alternatives, all SNF would be transported to the Hanford Site, the Idaho National Engineering Laboratory, the Savannah River Site, the Oak Ridge Reservation, or the Nevada Test Site. The primary difference between these alternatives, in terms of shipments, is the transport of N-Reactor SNF, naval-type SNF, and Savannah River Site production reactor SNF and targets. For Centralization at the Idaho National Engineering Laboratory, the Savannah River Site, the Oak Ridge Reservation, or the Nevada Test Site, N-Reactor SNF would be transported from the Hanford Site. For Centralization at the Hanford Site, the Idaho National Engineering Laboratory, the Oak Ridge Reservation, or the Nevada Test Site, Savannah River Site production reactor SNF and targets would be transported. For Centralization at the Hanford Site, the Savannah River Site, the Oak Ridge Reservation, or the Nevada Test Site, naval-type SNF would be transported from the Idaho National Engineering Laboratory. For Centralization at the Oak Ridge Reservation or the Nevada Test Site, N-Reactor SNF, naval-type SNF, and Savannah River Site production reactor SNF and targets would be transported.

Table I-2. Spent nuclear fuel shipments for the Decentralization, 1992/1993 Planning Basis, Regionalization by Fuel Type, and Centralization alternatives.

		Decentralization		1992/1993 Planning Basis		Regionalization by Fuel Type		Centralization									
								HS		SRS		INEL		ORR		NTS	
Origin	Destination	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
Naval-Type																	
INEL	HS							383	104								
	NTS															383	104
	ORR													383	104		
	SRS									383	104						
Savannah River Production																	
SRS	HS							484	97								
	INEL											484	97				
	ORR													484	97		
	NTS															484	97
ORR	SRS					1	1										
Hanford Production																	
HS	INEL											1192	605				
	SRS									1192	605						
	ORR													1192	605		
	NTS															1192	605
ORR	INEL					1	1										
Graphite																	
FSV	HS							244	35								
	INEL			244	35	244	35					244	35				
	SRS									244	35						
	ORR													244	35		
	NTS															244	35
INEL	HS							162	23								
	SRS									162	23						
	ORR													162	23		
	NTS															162	23
Domestic non-DOE																	
AFRRI	HS							3	3								

	INEL			3	3	3	3					3	3
	SRS	3	3							3	3		
	ORR											3	3
	NTS											3	3
USGS	HS							6	6				
	INEL	6	6	6	6	6	6					6	6
	SRS									6	6		
	ORR											6	6
	NTS											6	6
Domestic non-DOE													
NIST	HS							185	185				
	INEL											185	185
	SRS	185	185	185	185	18	185			185	185		
	ORR											185	185
	NTS											185	185
USAF	HS							3	3				
	INEL	3	3	3	3	3	3					3	3
	SRS									3	3		
	ORR											3	3
	NTS											3	3
DOW	HS							3	3				
	INEL	3	3	3	3	3	3					3	3
	SRS									3	3		
	ORR											3	3
	NTS											3	3
GE	HS							4	4				
	INEL	4	4	4	4							4	4
	SRS					4	4			4	4		
	ORR											4	4
	NTS											4	4
GA	HS							8	8				
	INEL	8	8	8	8	8	8					8	8
	SRS									8	8		
	ORR											8	8
	NTS											8	8
AERO	HS							3	3				
	INEL	3	3	3	3	3	3					3	3
	SRS									3	3		
	ORR											3	3
	NTS											3	3
Universities													
Universiti	HS							519	519				
	INEL	261	261	261	261	116	116					519	519
	SRS	258	258	258	258	403	403			519	519		
	ORR											519	519
	NTS											519	519
WVDP	HS							83	4				
	INEL			83	4	83	4					83	4
	SRS									83	4		
	ORR											83	4
	NTS											83	4

B&W	HS					2	2				
	INEL	2	2	2	2					2	2
	SRS							2	2		
	ORR									2	2
	NTS									2	2
ORR	HS					7	2				
	INEL			7	2					7	2
	SRS							7	2		
	NTS									7	2
SRS	HS					27	5				
	INEL			27	5					27	5
	ORR									27	5
	NTS									27	5
HS	INEL			6	2					6	2
	SRS							6	2		
	ORR									6	2
	NTS									6	2
Commercial											
ANL-E	HS					1	1				
	INEL			1	1					1	1
	SRS							1	1		
	ORR									1	1
	NTS									1	1
INEL	HS					370	74				
	SRS							370	74		
	ORR									370	74
	NTS									370	74
DOE Research											
ORR	HS					113	24				
	INEL			46	10					113	24
	SRS	67	14	67	14			113	24		
	NTS									113	24
BNL	HS					71	14				
	INEL	35	7								
	SRS	35	7	71	14			71	14		
	ORR									71	14
	NTS									71	14
SNL	HS					27	6				
	INEL	12	3	12	3					27	6
	SRS	15	3	15	3			27	6		
	ORR									27	6
	NTS									27	6
LANL	HS					17	4				
	INEL	17	4							17	4
	SRS			17	4			17	4		
	ORR									17	4
	NTS									17	4
ANL-E	HS					10	2				
	INEL	10	2	10	2					10	2
	SRS							10	2		
	ORR									10	2
	NTS									10	2

HS INEL 5 1 518 39
518 39
SRS 518 39
ORR
518 39
NTS
518 39
INEL HS 1003 165
SRS 114 23 1003 165
ORR
1003 165
NTS
1003 165
SRS HS 353 71
INEL 94 19
353 71
ORR
353 71
NTS
353 71
Foreign
Points of HS 1008 1008
Entry
SRS 546 546 546 546 838 838 1008 1008
INEL 462 462 462 462 170 170
1008 1008
ORR
1008 1008
NTS
1008 1008
TOTAL 1,742 1,742 2,267 1,824 3,078 1,926 5,099 2,375 5,951 2,848
4,897 2,655 6,695 2,995 6,815 3,021
Acronyms
AERO Aerotest San Ramon, CA INEL Idaho National Engineering Laboratory
AFRRI Armed Forces Radiobiology Research Institute Bethesda, MD LANL Los Alamos National Laboratory
ANL-E Argonne National Laboratory-East NIST National Institute of Standards and Technology Gaithersburg, MD
B&W Babcock & Wilcox Company Lynchburg, VA NTS Nevada Test Site
BNL Brookhaven National Laboratory ORR Oak Ridge Reservation
DOE Department of Energy SNL Sandia National Laboratories
DOW Dow North America Midland, MI SRS Savannah River Site
FSV Fort St. Vrain Nuclear Generating Station USAF United States Air Force McClellan, CA
GA General Atomics San Diego, CA USGS United States Geological Survey Denver, CO
GE General Electric Pleasanton, CA WVDP West Valley Demonstration Project
HS Hanford Site

Table I-3. Spent nuclear fuel shipments for the Regionalization by Geography alternatives.

Regionalization by Geography

Origin Destination
HS and SRS INEL and SRS NTS and SRS HS and ORR
INEL and ORR NTS and ORR
truck rail truck rail truck rail truck rail
truck rail truck rail
Naval-Type
INEL HS 383 104 383 104
NTS 383 104
383 104
ORR
SRS
Savannah River Production
SRS HS
INEL
ORR 484 97
484 97 484 97
NTS
ORR SRS
Hanford Production
HS INEL 1192 605
1192 605
SRS
ORR
NTS 1192 605
1192 605
ORR INEL
Graphite
FSV HS 244 35 244 35

```
          INEL                        244   35
244            35
          SRS
          ORR
          NTS                                        244           35
244           35
INEL      HS            162   23                                           162          23
          SRS
          ORR
          NTS                                        162           23
162           23
Domestic non-DOE
AFRRI     HS
          INEL
          SRS           3     3       3     3        3             3
          ORR                                                              3            3       3
3       3             3
          NTS
USGS      HS            6     6                                            6            6
          INEL                        6     6                                                   6
6
          SRS
          ORR
          NTS                                        6             6
6             6
Domestic non-DOE
NIST      HS
          INEL
          SRS           185   185     185   185      185           185
          ORR                                                              185          185
185            185     185            185
          NTS
USAF      HS            3     3                                            3            3
          INEL                        3     3                                                   3
3
          SRS
          ORR
          NTS                                        3             3
3             3
DOW       HS
          INEL
          SRS           3     3       3     3        3             3
          ORR                                                              3            3       3
3       3             3
          NTS
GE        HS            4     4                                            4            4
          INEL                        4     4                                                   4
4
          SRS
          ORR
          NTS                                        4             4
4             4
GA        HS            8     8                                            8            8
          INEL                        8     8                                                   8
8
          SRS
          ORR
          NTS                                        8             8
8             8
AERO      HS            3     3                                            3            3
          INEL                        3     3                                                   3
3
          SRS
          ORR
          NTS                                        3             3
3             3
Universities
UniversitiHS            209   209                                          209          209
          INEL                        209   209
209            209
          SRS           310   310     310   310      310           310
          ORR                                                              310          310
310            310     310            310
          NTS                                        209           209
WVDP      HS
          INEL
          SRS           83    4       83    4        83            4
          ORR                                                              83           4
83             4       83            4
          NTS
B&W       HS
```

```
          INEL
          SRS           2     2       2     2       2             2
          ORR                                                             2            2       2
2       2             2
          NTS
ORR       HS
          INEL
          SRS           7     2       7     2       7             2
          NTS
SRS       HS
          INEL
          ORR                                                             27           5
27             5       27            5
          NTS
HS        INEL                        6     2                                                  6
2
          SRS
          ORR
          NTS                                       6             2
6             2
Commercial
ANL-E     HS
          INEL
          SRS           1     1       1     1       1             1
          ORR                                                             1            1       1
1       1             1
          NTS
INEL      HS            370   74                                          370          74
          SRS
          ORR
          NTS                                       370           74
370           74
DOE Research
ORR       HS
          INEL
          SRS           113   24      113   24      113           24
          NTS
BNL       HS
          INEL
          SRS           71    14      71    14      71            14
          ORR                                                             71           14
71             14      71            14
          NTS
SNL       HS            27    6                                           27           6
          INEL                        27    6
27             6
          SRS
          ORR
          NTS                                       27            6
27            6
LANL      HS            17    4                                           17           4
          INEL                        17    4
17             4
          SRS
          ORR
          NTS                                       17            4
17            4
ANL-E     HS
          INEL
          SRS           10    2       10    2       10            2
          ORR                                                             10           2
10             2       10            2
          NTS
HS        INEL                        518   39
518            39
          SRS
          ORR
          NTS                                       518           39
518           39
INEL      HS            1003  165                                         1003         165
          SRS
          ORR
          NTS                                       1003          165
1003          165
SRS       HS
          INEL
          ORR                                                             353          71
353            71      353           71
          NTS
Foreign
Points of HS            230   230                                         230          230
```

```
Entry
          SRS           778   778     778   778     778           778
          INEL                        230   230
230          230
          ORR                                                             778          778
778          778     778          778
          NTS
230         230
          TOTAL         4,235 2,202   4,033 2,482   5,951         2,848   4,979        2,349
4,777        2,629   6,695        2,995
```

Acronyms

AERO	Aerotest San Ramon, CA	INEL	Idaho National Engineering Laboratory
AFRRI	Armed Forces Radiobiology Research Institute Bethesda, MD	LANL	Los Alamos National Laboratory
ANL-E	Argonne National Laboratory-East	NIST	National Institute of Standards and Technology Gaithersburg, MD
B&W	Babcock & Wilcox Company Lynchburg, VA		
BNL	Brookhaven National Laboratory	NTS	Nevada Test Site
DOE	Department of Energy	ORR	Oak Ridge Reservation
DOW	Dow North America Midland, MI	SNL	Sandia National Laboratories
FSV	Fort St. Vrain Nuclear Generating Station	SRS	Savannah River Site
GA	General Atomics San Diego, CA	USAF	United States Air Force McClellan, CA
GE	General Electric Pleasanton, CA	USGS	United States Geological Survey Denver, CO
HS	Hanford Site	WVDP	West Valley Demonstration Project

I-4 INCIDENT-FREE TRANSPORTATION RISKS FOR SPENT NUCLEAR FUEL

I-4.1 Methodology

Radiological dose during normal, incident-free transportation of SNF results from exposure to the external radiation field that surrounds the shipping containers. The dose is a function of the number of people exposed, their proximity to the containers, their length of time of exposure, and the intensity of the radiation field surrounding the containers.

Radiological impacts were determined for crew workers and the general population during normal, incident-free transportation. For truck shipments, the crew were the drivers of the transport vehicle. For rail shipments, the crew were workers in close proximity to the shipping containers during inspection or classification of railcars. The general population was persons within 800 meters (2,625 feet) of the road or railway (off-link), persons sharing the road or railway (on-link), and persons at stops.

Collective doses for the crew and general population were calculated using the RADTRAN 4 computer code (Neuhauser and Kanipe 1992). SNF was assigned a dose rate of 14 millirem per hour at 1 meter (3.28 feet) from the shipping container. This dose rate yields a dose rate of 10 millirem per hour at 2 meters (6.56 feet) from the vehicle, which is the regulatory maximum based on an exclusive use vehicle (see Madsen et al. 1986). A dose rate of 1 millirem per hour at 1 meter (3.28 feet) was used for naval-type SNF shipments, based on measured dose rates from previous naval SNF shipments. Three population density zones (rural, suburban, and urban) were used. These zones correspond to mean population densities of 6,719, and 3,861 persons per square kilometer, respectively (Neuhauser and Kanipe 1992).

Calculating the collective doses is based on developing unit risk factors. Unit risk factors provide an estimate of the impact from transporting one shipment of radioactive material over a unit distance of travel in a given population density zone. The unit risk factors may be combined with routing information, such as the transport distances in various population density zones, to determine the risk for a single shipment (a shipment risk factor) between a given origin and destination. Cashwell et al. (1986) contains a detailed explanation of the use of unit risk factors.

Unit risk factors were developed based on travel within rural, suburban, and urban population zones using RADTRAN 4, using default data (see Neuhauser and Kanipe 1992). Table I-4 contains the unit risk factors for offsite truck and rail shipments of SNF. Table I-5 contains the unit risk factors for offsite truck and rail shipments of naval-type SNF. Shipment risk factors were also developed for offsite shipments by combining the unit risk factors with routing information derived from the HIGHWAY and INTERLINE computer codes.

Table I-4. Incident-free unit risk factors for offsite truck and rail shipments of spent nuclear fuel.

		Unit risk factors (person-rem per kilometer)(a)		
Mode	Exposure group	Rural	Suburban	Urban
Truck				
	Occupational	4.6 X 10^-5	1.0 X 10^-4	1.7 X 10^-4
	General population			
	Off-link(b)	1.2 X 10^-7	1.6 X 10^-5	1.1 X 10^-4
	On-link(c)	5.0 X 10^-6	1.5 X 10^-5	1.5 X 10^-4
	Stops	1.2 X 10^-4	1.2 X 10^-4	1.2 X 10^-4
	General population total	1.3 X 10^-4	1.5 X 10^-4	3.8 X 10^-4
Rail				
	Occupationald	1.0 X 10^-5	1.0 X 10^-5	1.0 X 10^-5
	General population			
	Off-link(b)	1.7 X 10^-7	3.3 X 10^-5	2.9 X 10^-4
	On-link(c)	6.6 X 10^-8	8.5 X 10^-7	2.4 X 10^-6
	Stopse	4.8 X 10^-6	4.8 X 10^-6	4.8 X 10^-6
	General population total	5.0 X 10^-6	3.8 X 10^-5	3.0 X 10^-4

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a. The methodology, equations, and data used to develop the unit risk factors are discussed in Madsen et al. (1986) and Neuhauser and Kanipe (1992). Cashwell et al. (1986) contains a detailed explanation of the use of unit risk factors.

b. Off-link general population were persons within 800 meters (2,625 feet) of the road or railway.

c. On-link general population were persons sharing the road or railway.

d. The nonlinear component of incident-free rail dose for crew workers because of railcar inspections and classifications is 0.011 person-rem per shipment. Ostmeyer (1986) contains a detailed explanation of the rail exposure model.

e. The nonlinear component of incident-free rail dose for the general population because of railcar inspections and classifications is 0.0087 person-rem per shipment. Ostmeyer (1986) contains a detailed explanation of the rail exposure model.

Table I-5. Incident-free unit risk factors for truck and rail shipments of naval-type spent nuclear fuel.

		Unit risk factors (person-rem per kilometer)(a)		
Mode	Exposure group	Rural	Suburban	Urban
Truck				
	Occupational	1.5 X 10^-5	3.3 X 10^-5	5.4 X 10^-5
	General population			

	Off-link(b)	8.8 X 10^-9	1.2 X 10^-6	7.7 X 10^-6
	On-link(c)	3.6 X 10^-7	1.0 X 10^-6	1.1 X 10^-5
	Stops	4.3 X 10^-6	4.3 X 10^-6	4.3 X 10^-6
	General population total	4.7 X 10^-7	6.5 X 10^-6	2.3 X 10^-5
Rail				
	Occupationald	7.2 X 10^-7	7.2 X 10^-7	7.2 X 10^-7
	General population			
	Off-link(b)	1.2 X 10^-8	2.3 X 10^-6	2.1 X 10^-5
	On-link(c)	4.7 X 10^-9	6.1 X 10^-8	1.7 X 10^-7
	Stopse	3.4 X 10^-7	3.4 X 10^-7	3.4 X 10^-7
	General population total	3.6 X 10^-7	2.7 X 10^-6	2.1 X 10^-5

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a. The methodology, equations, and data used to develop the unit risk factors are discussed in Madsen et al. (1986) and Neuhauser and Kanipe (1992). Cashwell et al. (1986) contains a detailed explanation of the use of unit risk factors.

b. Off-link general population were persons within 800 meters (2,625 feet) of the road or railway.

c. On-link general population were persons sharing the road or railway.

d. The nonlinear component of incident-free rail dose for crew workers because of railcar inspections and classifications is 0.00080 person-rem per shipment. Ostmeyer (1986) contains a detailed explanation of the rail exposure model.

e. The nonlinear component of incident-free rail dose for the general population because of railcar inspections and classifications is 0.00062 person-rem per shipment. Ostmeyer (1986) contains a detailed explanation of the rail exposure model.

Incident-free nonradiological fatalities were also estimated using unit risk factors. These unit risk factors account for the fatalities associated with exhaust emissions, but the distances used to estimate the impacts must be doubled to reflect the round trip distance because these impacts occur whether or not the shipment contains radioactive material. Two sets of data were evaluated: (a) data from the Non-Radiological Impacts of Transporting Radioactive Material (Rao et al. 1982), and (b) data from the Motor Vehicle-Related Air Toxics Study (EPA 1993). In Rao et al. (1982), the nonradiological unit risk factor for trucks was 1.0 10-7 fatalities per kilometer and the nonradiological unit risk factor for trains was 1.3 10-7 fatalities per kilometer. These unit risk factors are applicable only in urban areas. In EPA (1993), the unit risk factor was calculated to be 7.2 10-11 fatalities per kilometer; this unit risk factor is applicable in all areas (i.e., rural, suburban, and urban). Based on the routes analyzed in this EIS, the unit risk factors from Rao et al. (1982) were found to overestimate impacts by about 20 to 30 times relative to the unit risk factors from EPA (1993). Therefore, the unit risk factors from Rao et al. (1982) were used as a conservative estimate of the incident-free nonradiological fatalities presented in this EIS. It should be noted that the unit risk factors from Rao et al. (1982) account for all fatalities, not just cancer fatalities. Other effects of chronic exposure to diesel exhaust emissions have been followed in occupationally exposed workers, but these data are insufficient to make a correlation between the effects and the exposure experienced (EPA 1993). Therefore, these impacts were not estimated in this EIS.

I-4.1.1 Maximally Exposed Individual Exposure Scenarios

Maximum individual doses were calculated using the RISKIND computer code (Yuan et al. 1993). The maximum individual doses for the routine transport offsite were estimated for transportation workers, as well as members of the general population. For rail shipments, the three general population scenarios were (a) a railyard worker working at a distance of 10 meters (32.8 feet) from the shipping container for 2 hours, (b) a resident living 30 meters (98.4 feet) from the rail line where the shipping container was being transported, and (c) a resident living 200 meters (656.2 feet) from a rail stop where the shipping container was sitting for 20 hours. For train shipments, the maximum exposed transportation worker was an individual in a railyard who spent a time- and distance-weighted average of 0.16 hours inspecting, classifying, and repairing railcars (Wooden 1986).

For offsite truck shipments, the three scenarios for the general population were: (a) a person caught in traffic and located 1 meter (3.28 feet) away from the surface of the shipping container for one-half hour, (b) a resident living 30 meters (98.4 feet) from the highway used to transport the shipping container, and (c) a service station worker working at a distance of 20 meters (65.6 feet) from the shipping container for 2 hours. The hypothetical maximum exposed individual radiological doses were accumulated over the 40-year period. However, for the situation involving an individual caught in traffic next to a truck, the radiological exposures were calculated for only one event because it was considered unlikely that the same individual would be caught in traffic next to all containers for all shipments. For truck shipments, the maximum exposed transportation worker is the driver who was assumed to drive shipments for up to 2,000 hours per year.

I-4.2 Results of Calculations

This section summarizes the results of the incident-free transportation analyses for SNF shipments that occur outside the boundaries of U.S. Department of Energy sites (offsite). These results do not include the impacts of SNF shipments within the boundaries of DOE sites (onsite). Onsite transportation impacts are addressed in site-specific Appendices A, B, C, D, and F of this EIS.

This section includes the impacts of offsite transport of naval-type SNF stored at the Idaho Chemical Processing Plant as of June 1995 to storage locations at other DOE sites, as identified in the alternatives. Shipments of naval SNF and test specimens are addressed in Appendix D of Volume 1 of this EIS.

I-4.2.1 Impacts from the No Action Alternative

Under the No Action alternative, the only offsite transport of SNF involves shipments of naval SNF and test specimens. These shipments are addressed in Appendix D of Volume 1 of this EIS.

I-4.2.2 Impacts from the Decentralization Alternative

For the Decentralization alternative, the incident-free transportation of SNF was estimated to result 0.11 to 0.34 fatalities over the 40-year period 1995 through 2035 (see Table I-6). The statistically estimated fatalities were the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions. A range of fatalities occurs because of the option of using truck or rail transport for SNF shipments.

The estimated number of radiation-related latent cancer fatalities for transportation workers ranged from 0.023 to 0.082. The estimated number of radiation-related latent cancer fatalities for the general population ranged from 0.041 to 0.24. The estimated number of nonradiological fatalities from vehicular emissions ranged from 0.017 to 0.044.

I-4.2.3 Impacts from the 1992/1993 Planning Basis Alternative

For the 1992/1993 Planning Basis alternative, the incident-free transportation of SNF was estimated to result in total fatalities that ranged from 0.11 to 0.42 over the 40-year period 1995 through 2035 (see Table I-7). These fatalities were the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological

Table I-6. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for the Decentralization alternative (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	48	1.8	93	3.4	20	0.73	160	5.9
Collective dose (person-rem)	59	16	130	37	15	5.0	200	58
Estimated latent cancer fatalities	0.024	0.0064	0.052	0.015	0.0060	0.0020	0.080	0.023
General population								
Maximum individual dose (rem)	0.21	0.87	0.41	1.7	0.088	0.36	0.71	2.9
Collective dose (person-rem)	140	29	310	43	18	8.0	470	80
Estimated latent cancer fatalities	0.070	0.015	0.16	0.022	0.0090	0.0040	0.24	0.040
Estimated nonradiological fatalities	0.0050	0.012	0.010	0.027	0.0023	0.0051	0.017	0.044

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a. Maheras (1995a).

b. Maheras (1995b).

c. Maheras (1995c).

d. DOE SNF includes special-case commercial, DOE research, other domestic research, graphite, N-Reactor, naval-type, and Savannah River production reactor SNF (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-7. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for the 1992/1993 Planning Basis alternative (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail

Occupational								
Maximum individual dose (rem)	37	1.8	71	3.4	52	1.0	160	6.2
Collective dose (person-rem)	59	16	130	37	66	7.3	260	60
Estimated latent cancer fatalities	0.024	0.0064	0.052	0.015	0.026	0.0029	0.10	0.024
General population								
Maximum individual dose (rem)	0.21	0.87	0.41	1.7	0.30	0.50	0.92	3.1
Collective dose (person-rem)	140	29	310	43	140	12	590	84
Estimated latent cancer fatalities	0.070	0.015	0.16	0.022	0.070	0.0060	0.30	0.042
Estimated nonradiological fatalities	0.0050	0.012	0.010	0.027	0.0054	0.0065	0.020	0.046

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a. Maheras (1995a).

b. Maheras (1995b).

c. Maheras (1995c).

d. DOE SNF includes special-case commercial, DOE research, other domestic research, graphite, N-Reactor, naval-type, and Savannah River production reactor SNF (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

fatalities from vehicular emissions. Again, a range of fatalities occurred because of the option of using truck or rail transport for SNF shipments.

The estimated number of radiation-related latent cancer fatalities for transportation workers ranged from 0.024 to 0.10. The estimated number of radiation-related latent cancer fatalities for the general population ranged from 0.043 to 0.30. The estimated number of nonradiological fatalities from vehicular emissions ranged from 0.020 to 0.046.

I-4.2.4 Impacts from the Regionalization Alternative

I-4.2.4.1 Impacts from Regionalization by Fuel Type. For the Regionalization by Fuel

Type, the incident-free transportation of SNF was estimated to result in total fatalities that ranged from 0.14 to 0.58 over the 40-year period 1995 through 2035 (see Table I-8). These fatalities were the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions. The reason for a range of fatalities was because of the option of using truck or rail transport for SNF shipments.

The estimated number of radiation-related latent cancer fatalities for transportation workers ranged from 0.026 to 0.14. The estimated number of radiation-related latent cancer fatalities for the general population ranged from 0.053 to 0.41. The estimated number of nonradiological fatalities from vehicular emissions ranged from 0.027 to 0.059.

I-4.2.4.2 Impacts from Regionalization by Geography. For the six Regionalization by

Geography alternatives, the incident-free transportation of SNF was estimated to result in total fatalities that ranged from 0.10 for regionalization at the Idaho National Engineering Laboratory and Oak Ridge Reservation to 0.85 for regionalization at the Nevada Test Site and the Oak Ridge Reservation (see Tables I-9 through I-14). These fatalities were over the 40-year period 1995 through 2035 and were the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

The reason for a range of fatalities was because of two factors: (a) the option of using truck or rail transport for SNF shipments, and (b) the six regionalization by geography alternatives.

For regionalization at the Idaho National Engineering Laboratory and Oak Ridge Reservation, the estimated number of radiation-related latent cancer fatalities for transportation workers was 0.028. The estimated number of radiation-related latent cancer fatalities for the general population was 0.042. The estimated number of nonradiological fatalities from vehicular emissions was 0.034.

For regionalization at the Nevada Test Site and the Oak Ridge Reservation, the estimated number of radiation-related latent cancer fatalities for transportation workers was 0.20. The estimated

Table I-8. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for Regionalization by Fuel Type (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	27	1.8	52	3.4	81	1.3	160	6.5
Collective dose (person-rem)	54	15	150	41	150	11	350	67
Estimated latent cancer fatalities	0.022	0.0060	0.060	0.016	0.060	0.0044	0.14	0.027
General population								
Maximum individual dose (rem)	0.21	0.87	0.41	1.7	0.63	0.67	1.3	3.2
Collective dose (person-rem)	120	33	350	54	340	17	810	100
Estimated latent cancer fatalities	0.060	0.017	0.18	0.027	0.17	0.0085	0.41	0.050
Estimated nonradiological fatalities	0.0051	0.014	0.012	0.037	0.0098	0.0081	0.027	0.059

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a. Maheras (1995a).

b. Maheras (1995b).

c. Maheras (1995c).

d. DOE SNF includes special-case commercial, DOE research, other domestic research, graphite, N-Reactor, naval-type, and Savannah River production reactor SNF (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-9. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for Regionalization by Geography at the Hanford Site and Savannah River Site (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	

	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	20	1.8	38	3.4	100	2.3	160	7.5
Collective dose (person-rem)	60	17	99	31	150	13	310	61
Estimated latent cancer fatalities	0.024	0.0068	0.040	0.012	0.060	0.0052	0.12	0.024
General population								
Maximum individual dose (rem)	0.21	0.87	0.41	1.7	1.1	1.1	1.7	3.7
Collective dose (person-rem)	140	30	230	44	330	18	700	92
Estimated latent cancer fatalities	0.070	0.015	0.012	0.022	0.17	0.0090	0.35	0.046
Estimated nonradiological fatalities	0.0050	0.012	0.0076	0.031	0.010	0.0084	0.023	0.051

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a. Maheras (1995a).

b. Maheras (1995b).

c. Maheras (1995c).

d. DOE SNF includes special-case commercial, DOE research, other domestic research, graphite, N-Reactor, naval-type, and Savannah River production reactor SNF (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-10. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for Regionalization by Geography at the Idaho National Engineering Laboratory and Savannah River Site (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	21	1.8	40	3.4	99	3.2	160	8.4
Collective dose (person-rem)	54	15	100	32	140	21	290	68
Estimated latent cancer fatalities	0.022	0.0060	0.040	0.013	0.056	0.0084	0.12	0.027
General population								
Maximum individual dose (rem)	0.21	0.87	0.41	1.7	1.0	1.6	1.6	4.2
Collective dose (person-rem)	120	28	230	42	320	25	670	95
Estimated latent cancer fatalities	0.060	0.014	0.12	0.021	0.16	0.013	0.34	0.048
Estimated nonradiological fatalities	0.0046	0.011	0.0081	0.028	0.0083	0.0087	0.021	0.048

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a. Maheras (1995a).

b. Maheras (1995b).

c. Maheras (1995c).

d. DOE SNF includes special-case commercial, DOE research, other domestic research, graphite, N-Reactor, naval-type, and Savannah River production reactor SNF (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-11. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for Regionalization by Geography at the Nevada Test Site and Savannah River Site (1995 to 2035).

	Spent nuclear fuel type							
	Universitya		Foreignb		DOEc,d		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	14	1.8	27	3.4	120	4.5	160	9.7
Collective dose (person-rem)	56	17	110	31	330	34	500	82
Estimated latent cancer fatalities	0.022	0.0068	0.044	0.012	0.13	0.014	0.20	0.033
General population								
Maximum individual dose (rem)	0.21	0.87	0.41	1.7	1.8	2.2	2.4	4.8
Collective dose (person-rem)	130	29	250	45	780	37	1200	110
Estimated latent cancer fatalities	0.065	0.015	0.13	0.023	0.39	0.019	0.60	0.055
Estimated nonradiological fatalities	0.0053	0.012	0.0076	0.031	0.040	0.012	0.053	0.055

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a. Maheras (1995a).

b. Maheras (1995b).

c. Maheras (1995c).

d. DOE SNF includes special-case commercial, DOE research, other domestic research, graphite, N-Reactor, naval-type, and Savannah River production reactor SNF (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-12. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for Regionalization by Geography at the Hanford Site and Oak Ridge Reservation (1995 to 2035).

	Spent nuclear fuel type							
	Universitya		Foreignb		DOEc,d		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	17	1.8	32	3.4	110	2.8	160	8.0
Collective dose (person-rem)	56	16	94	29	170	17	320	62
Estimated latent cancer fatalities	0.022	0.0064	0.038	0.012	0.068	0.0068	0.13	0.025
General population								
Maximum individual dose (rem)	0.21	0.87	0.41	1.7	1.4	1.4		

							2.0	4.0
Collective dose (person-rem)	130	26	220	33	390	22	740	81
Estimated latent cancer fatalities	0.065	0.013	0.11	0.017	0.20	0.011	0.37	0.041
Estimated nonradiological fatalities	0.0049	0.0087	0.0066	0.020	0.012	0.0090	0.024	0.038

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a. Maheras (1995a).

b. Maheras (1995b).

c. Maheras (1995c).

d. DOE SNF includes special-case commercial, DOE research, other domestic research, graphite, N-Reactor, naval-type, and Savannah River production reactor SNF (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-13. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for Regionalization by Geography at the Idaho National Engineering Laboratory and Oak Ridge Reservation (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	17	1.8	34	3.4	110	3.7	160	8.9
Collective dose (person-rem)	50	15	95	29	170	24	320	68
Estimated latent cancer fatalitie	0.020	0.0060	0.038	0.012	0.068	0.0096	0.13	0.027
General population								
Maximum individual dose (rem)	0.21	0.87	0.41	1.7	1.3	1.8	1.9	4.4
Collective dose (person-rem)	110	23	220	30	380	30	710	83
Estimated latent cancer fatalitie	0.055	0.012	0.11	0.015	0.19	0.015	0.36	0.042
Estimated nonradiological fatalit	0.0046	0.0077	0.0071	0.017	0.010	0.0094	0.022	0.034

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a. Maheras (1995a).
b. Maheras (1995b).

c. Maheras (1995c).

d. DOE SNF includes special-case commercial, DOE research, other domestic research, graphite, N-Reactor, naval-type, and Savannah River production reactor SNF (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-14. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for Regionalization by Geography at the Nevada Test Site and Oak Ridge Reservation (1995 to 2035).

Spent nuclear fuel type

	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	12	1.8	24	3.4	120	5.0	160	10
Collective dose (person-rem)	52	16	100	29	360	37	510	82
Estimated latent cancer fatalities	0.021	0.0064	0.040	0.012	0.14	0.015	0.20	0.033
General population								
Maximum individual dose (rem)	0.21	0.87	0.41	1.7	2.1	2.5	2.7	5.1
Collective dose (person-rem)	120	25	240	33	840	42	1200	100
Estimated latent cancer fatalities	0.060	0.013	0.12	0.017	0.42	0.021	0.60	0.050
Estimated nonradiological fatalities	0.0052	0.0083	0.0066	0.021	0.042	0.013	0.054	0.042

a. Maheras (1995a).

b. Maheras (1995b).

c. Maheras (1995c).

d. DOE SNF includes special-case commercial, DOE research, other domestic research, graphite, N-Reactor, naval-type, and Savannah River production reactor SNF (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

number of radiation-related latent cancer fatalities for the general population was 0.60. The estimated number of nonradiological fatalities from vehicular emissions was 0.054.

I-4.2.5 Impacts from the Centralization Alternatives

For the five Centralization alternatives, the incident-free transportation of spent nuclear fuel was estimated to result in total fatalities that ranged from 0.16 for centralization at the Oak Ridge Reservation to 1.7 for centralization at the Savannah River Site (see Tables I-15 through I-19). These fatalities were over the 40-year period 1995 through 2035 and were the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

The reason for a range of fatalities was because of two factors: (a) the option of using truck or rail transport for SNF shipment and (b) the five Centralization options.

For centralization at the Oak Ridge Reservation, the estimated number of radiation-related latent cancer fatalities for transportation workers was 0.042. The estimated number of radiation-related latent cancer fatalities for the general population was 0.067. The estimated number of nonradiological fatalities from vehicular emissions was 0.055.

For centralization at the Savannah River Site, the estimated number of radiation-related latent cancer fatalities for transportation workers was 0.42. The estimated number of radiation-related latent cancer fatalities for the general population was 1.2. The estimated number of nonradiological fatalities from vehicular emissions was 0.074.

I-4.2.6 Impacts of Using Alternate Points of Entry for Foreign Research Reactor Spent Nuclear Fuel Shipments

For incident-free transportation (radiological and vehicle-related), shipments from Jacksonville, Florida, and Wilmington, North Carolina, to the Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, Oak Ridge Reservation, and Nevada Test Site would yield lower impacts than shipments from Charleston, South Carolina, Galveston, Texas, Hampton Roads, Virginia, Savannah, Georgia, and the Military Ocean Terminal, Sunny Point, North Carolina, to these same sites.

Table I-15. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for the Centralization at the Hanford Site alternative (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	16	1.8	32	3.4	110	2.9	160	8.1
Collective dose (person-rem)	100	26	220	56	430	32	750	110
Estimated latent cancer fatalities	0.040	0.010	0.088	0.022	0.17	0.013	0.30	0.044
General population								
Maximum individual dose (rem)	0.21	0.87	0.41	1.7	1.5	1.4	2.1	4.0
Collective dose (person-rem)	250	38	560	56	990	45	1800	140
Estimated latent cancer fatalities	0.13	0.019	0.28	0.028	0.50	0.023	0.90	0.070
Estimated nonradiological fatalities	0.0057	0.014	0.016	0.035	0.026	0.024	0.048	0.073

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a. Maheras (1995a).

b. Maheras (1995b).

c. Maheras (1995c).

d. DOE SNF includes special-case commercial, DOE research, other domestic research, graphite, N-Reactor, naval-type, and Savannah River production reactor SNF (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-16. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for the Centralization at the Idaho National Engineering Laboratory alternative (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	17	1.8	33	3.4	110	3.8	160	9.0
Collective dose (person-rem)	86	22	190	49	380	36	660	110

Estimated latent cancer fatalities	0.034	0.0088	0.076	0.020	0.15	0.014	0.26	0.044
General population								
Maximum individual dose (rem)	0.21	0.87	0.41	1.7	1.4	1.9	2.0	4.5
Collective dose (person-rem)	210	33	490	49	880	49	1600	130
Estimated latent cancer fatalities	0.11	0.017	0.25	0.025	0.44	0.025	0.80	0.065
Estimated nonradiological fatalities	0.0049	0.012	0.015	0.031	0.022	0.023	0.042	0.066

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a. Maheras (1995a).

b. Maheras (1995b).

c. Maheras (1995c).

d. DOE SNF includes special-case commercial, DOE research, other domestic research, graphite, N-Reactor, naval-type, and Savannah River production reactor SNF (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-17. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for the Centralization at the Savannah River Site alternative (1995 to 2035).

	Spent nuclear fuel type							
	Universitya		Foreignb		DOEc,d		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	14	1.8	27	3.4	120	4.5	160	9.7
Collective dose (person-rem)	53	15	140	40	840	60	1000	120
Estimated latent cancer fatalities	0.021	0.006	0.056	0.016	0.34	0.024	0.40	0.048
General population								
Maximum individual dose (rem)	0.21	0.87	0.41	1.7	1.8	2.2	2.4	4.8
Collective dose (person-rem)	110	34	330	54	1900	85	2300	170
Estimated latent cancer fatalities	0.055	0.017	0.17	0.027	0.95	0.043	1.2	0.085
Estimated nonradiological fatalities	0.0050	0.014	0.012	0.037	0.057	0.032	0.074	0.083

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a. Maheras (1995a).

b. Maheras (1995b).

c. Maheras (1995c).

d. DOE SNF includes special-case commercial, DOE research, other domestic research, graphite, N-Reactor, naval-type, and Savannah River production reactor SNF (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-18. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for the Centralization at the Oak Ridge Reservation alternative (1995 to 2035).

Spent nuclear fuel type

	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	12	1.8	24	3.4	120	5.0	160	10
Collective dose (person-rem)	42	13	130	36	750	58	920	110
Estimated latent cancer fatalities	0.017	0.0052	0.052	0.014	0.30	0.023	0.37	0.044
General population								
Maximum individual dose (rem)	0.21	0.87	0.41	1.7	2.1	2.5	2.7	5.1
Collective dose (person-rem)	91	25	310	39	1800	68	2200	130
Estimated latent cancer fatalities	0.046	0.013	0.16	0.02	0.90	0.034	1.1	0.065
Estimated nonradiological fatalities	0.0042	0.0091	0.0097	0.023	0.043	0.023	0.057	0.055

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a. Maheras (1995a).

b. Maheras (1995b).

c. Maheras (1995c).

d. DOE SNF includes special-case commercial, DOE research, other domestic research, graphite, N-Reactor, naval-type, and Savannah River production reactor SNF (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-19. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for the Centralization at the Nevada Test Site alternative (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	12	1.8	24	3.4	120	5.0	160	10
Collective dose (person-rem)	94	25	230	54	590	52	910	130
Estimated latent cancer fatalities	0.038	0.010	0.092	0.022	0.24	0.021	0.36	0.052
General population								
Maximum individual dose (rem)	0.21	0.87	0.41	1.7	2.2	2.5	2.8	5.1
Collective dose (person-rem)	230	37	540	56	1400	64	2200	160
Estimated latent cancer fatalities	0.12	0.019	0.27	0.028	0.70	0.032	1.1	0.080
Estimated nonradiological fatalities	0.0066	0.013	0.016	0.037	0.059	0.028	0.082	0.078

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a. Maheras (1995a).

b. Maheras (1995b).

c. Maheras (1995c).

d. DOE SNF includes special-case commercial, DOE research, other domestic research, graphite, N-Reactor, naval-type, and Savannah

River production reactor SNF (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

I-5 SPENT NUCLEAR FUEL TRANSPORTATION ACCIDENT RISKS AND MAXIMUM REASONABLY FORESEEABLE CONSEQUENCES

I-5.1 Methodology

The offsite SNF transportation accident analysis considers the impacts of accidents during the transportation of SNF by truck or rail. SNF is transported in specially designed casks that meet U.S. Department of Transportation and U.S. Nuclear Regulatory Commission Type B packaging specifications in 10 CFR Part 71 (CFR 1994b).

Under accident conditions, impacts to human health and the environment may result from the release and dispersal of radioactive material. Because of the rigorous design specifications for SNF shipping casks, the U.S. Nuclear Regulatory Commission has estimated that casks will withstand 99.4 percent of truck or rail accidents without sustaining damage sufficient to breach the cask (Fischer et al. 1987). The 0.6 percent of accidents that could potentially breach the cask are represented by a spectrum of accident severities and radioactive release conditions. Accident analysis methodology has been developed by the U.S. Nuclear Regulatory Commission for calculating the probabilities and consequences from this spectrum of unlikely accidents, but it is not possible to predict where along the shipping route such accidents might occur.

To provide DOE and the public a reasonable assessment of SNF transportation accident impacts, two types of analyses were performed. First, an accident risk assessment was performed that takes into account the probabilities and consequences of a spectrum of accident severities using methodology developed by the U.S. Nuclear Regulatory Commission (Fischer et al. 1987). The accident risk assessment used route-specific information for accident rates and population densities. For the spectrum of accidents considered in the analysis, accident consequences in terms of collective dose to the population within 80 kilometers (50 miles) were multiplied by the accident probabilities to yield dose risk using the RADTRAN 4 computer code. Second, to represent the maximum reasonably foreseeable impacts to individuals and populations should an accident occur, radiological consequences were calculated for an accident of maximum reasonably foreseeable severity in each population zone. An accident is considered reasonably foreseeable if its probability of occurrence is greater than 1 10-7 per year. The accident consequence assessment for maximally exposed individuals and population groups was performed using the RISKIND computer code.

An important variable in the assessment of impacts from SNF transportation accidents is the type of SNF. A wide range of SNF types exists within the DOE complex with significant differences in radioactive material content, fuel material design, cladding design, reactor operating history, and storage (cooling time) history. These differences among SNF types translate into different radioactive material release characteristics under accident conditions. To account for the variation in SNF types, analyses were performed for the following representative SNF types: (a) naval reactor fuels, (b) Savannah River Production Reactor fuels, (c) Hanford N-Reactor fuels, (d) graphite fuels, (e) special-case commercial reactor fuels, (f) university research/test reactor fuels, (g) DOE research/test reactor fuels, (h) foreign research reactor fuels, and (i) non-DOE research reactor fuels.

The impacts for specific alternatives were calculated in units of dose (person-rem) for each origin and destination pair associated with each representative SNF type. The impacts are further expressed as health risks in terms of latent cancer fatalities in exposed populations. The health risk conversion factors used were derived from International Commission on Radiological Protection Publication 60 (ICRP 1991).

I-5.1.1 Accident Rates

For calculating accident shipment-risk factors, state-level accident rates were taken from data provided in Saricks and Kvitek (1994) for rail and heavy combination trucks. For truck transportation, separate accident rates were used for rural, suburban, and urban population density zones in each state. One average accident rate was used for each state for rail transportation. For truck transport, accident fatality risks were based on state-level rates for interstate highways in urban and rural areas (Saricks and Kvitek 1994). Accident fatality risks for rail transportation were calculated using a nationwide average rate of 2.64 10-8 fatalities per rail-kilometer (Cashwell et al. 1986).

I-5.1.2 Accident Severity Categories and Conditional Probabilities

Accident severity categories for potential SNF transportation accidents are described in a U.S. Nuclear Regulatory Commission report commonly referred to as the Modal Study (Fischer et al. 1987). The Modal Study classification scheme for both truck and rail transportation is shown in Figure I-1. Severity is described as a function of the magnitudes of the mechanical forces (impact) and thermal forces (fire) to which a cask may be subjected during an accident. Because all accidents can be described in these terms, severity is independent of the specific accident sequence. In other words, any sequence of events that results in an accident in which a cask is subjected to forces within a certain range of values is assigned to the accident severity category associated with that range. The accident severity scheme is designed to take into account all reasonably foreseeable transportation accidents, including accidents with low probability but high consequences and those with high probability but low consequences.

The severity category matrix represents a set of scenarios defined by a combination of mechanical and thermal forces. A conditional probability is assigned in each category as shown in Figure I-2. For example, Category R(1,1) accidents are the least severe but most frequent, whereas Category R(4,5) accidents are very severe but very infrequent. To determine the expected frequency of each severity category, the conditional probability in each category was multiplied by the baseline accident rate. Each population density zone has a distinct baseline accident rate and distribution

Figure I-1. Matrix of cask response regions for combined mechanical and thermal loads.
(Source: Fischer et al. 1987)

Figure I-2. Fraction of truck and rail accidents expected within each severity category,

assuming an accident occurs. (Source: Fischer et al. 1987).
of accident severities related to differences in average vehicle velocity, traffic density, and other factors, including rural, suburban, or urban location.

For the accident risk assessment, accident risk was generically defined as the consequences of an accident multiplied by the probability of the occurrence of that accident, an approach consistent with the methodology suggested by the existing RADTRAN computer code. Accident unit-risk factors were calculated using the RADTRAN 4 computer code, then summed over the accident conditional probabilities and route characteristics for the origin and destination pairs to yield risk per shipment estimates. These accident risk factors take into account the entire spectrum of reasonably foreseeable transportation accidents, including low probability accidents that have high consequences and high probability accidents that have low consequences.

For the maximum reasonably foreseeable accident consequence assessment, the doses were assessed for populations and individuals assuming the most severe accident scenario with a probability greater than 1 X 10^-7 per year. In terms of the radioactivity released to the environment, the most severe reasonably foreseeable accident is represented by eight accident severity categories [R(4,1) through R(4,5) and R(1,5) through R(3,5)]. Each of the eight most severe accident categories result in the same total release of radioactive material, but the conditional probabilities of occurrence vary. Therefore, the accident consequence assessment is based on a maximum reasonably foreseeable release of radioactivity with a conditional probability that is the sum of the conditional probabilities of the eight most severe accident categories. Accidents of this severity are extremely rare, occurring approximately once per 100,000 truck or 10,000 rail accidents involving a SNF shipment.

I-5.1.3 Atmospheric Conditions

Because it is impossible to predict the specific location of an offsite transportation accident, generic atmospheric conditions were selected for the risk and consequence assessments. For accident risk assessment, neutral weather conditions (Pasquill Stability Class D) were assumed. Neutral weather conditions are typified by moderate windspeeds, vertical mixing within the atmosphere, and good dispersion of atmospheric contaminants. Because neutral meteorological conditions compose the most frequently occurring atmospheric stability condition in the United States, these conditions are most likely to be present in the event of an accident involving a SNF shipment. On the basis of observations from National Weather Service surface meteorological stations at over 300 locations in the United States, on an annual average, neutral conditions (Pasquill Class C and D) occur 50 percent of the time, while stable (Pasquill Class E and F) and unstable (Pasquill Class A and B) conditions occur 33 percent and 17 percent of the time, respectively (Doty et al. 1976). The neutral category predominates in all seasons, but most frequently in the winter (nearly 60 percent of the observations). For the accident consequence assessment, doses were assessed under both neutral (Class D with 4 meters per second windspeed) and stable (Class F with 1 meter per second windspeed) atmospheric conditions. Stable weather conditions are typified by low windspeeds, very little vertical mixing within the atmosphere, and poor dispersion of atmospheric contaminants. Class F meteorology in combination with windspeeds of 1 meter per second generally occur no more than 5 percent of the time. Results calculated for neutral conditions represent the most likely consequences, and the results for stable conditions represent a worst-case weather situation.

I-5.1.4 Population Density Zones

Three population density zones (rural, suburban, and urban) were used for the offsite population risk assessment. These zones respectively correspond to mean population densities of 6, 719, and 3,861 persons per square kilometer. The three population density zones are based on an aggregation of the 12 population density zones provided in the HIGHWAY and INTERLINE output. For calculating, population density information was generated at the state level and used as RADTRAN input for the origin and destination pairs.

I-5.1.5 Exposure Pathways

Radiological doses were calculated for an individual located near the scene of the accident and for populations within 50 miles (80 kilometers) of the accident. Rural, suburban, and urban population densities were assessed. Dose calculations considered a variety of exposure pathways, including inhalation and direct exposure (cloudshine) from the passing cloud, ingestion from contaminated crops, direct exposure (groundshine) from radioactivity deposited on the ground, and inhalation of resuspended radioactive particles from the ground.

I-5.1.6 Health Risk Conversion Factors

The health risk conversion factors used to estimate expected latent cancer fatalities from radiological exposures were derived from International Commission on Radiological Protection Publication 60 (ICRP 1991): 5.0 10-4 and 4.0 10-4 latent fatal cancer cases per person-rem for members of the public and workers, respectively.

I-5.2 Spent Nuclear Fuel Characterization and Radioactive Release Characteristics

I-5.2.1 Characterization of Representative Spent Nuclear Fuel Types

Shipments of naval reactor SNF are addressed in Appendix D of Volume 1 of this EIS, with the exception of naval-type SNF that has been transferred from the U.S. Navy to the DOE and is currently in storage at the Idaho National Engineering Laboratory Idaho Chemical Processing Plant. Characterization data for naval-type SNF were derived from Appendix D of Volume 1 of this EIS.

Savannah River Site production reactor SNF was assumed to include both the spent driver fuel used to power the production reactors, as well as the quantities of irradiated plutonium target material currently in storage at the Savannah River Site. Spent driver fuel stored at the Savannah River Site includes fuel used in tritium and plutonium production. Analysis of these two fuel types showed that typical tritium production SNF contains a higher fission product and transuranic inventory than plutonium production SNF. Analysis of the characteristics of typical irradiated plutonium target material also showed that the radionuclide inventory would be bounded by the inventory in spent tritium production driver fuel. Therefore, for analysis purposes, both spent driver fuel and irradiated plutonium target material at the Savannah River Site was assumed to have the characteristics of spent tritium production driver fuel. Table I-20 shows the radionuclide inventory developed to represent Savannah River Site production reactor SNF based on published reports (WSRC 1991; WSRC 1990).

Characterization data for Hanford N-Reactor SNF were based on Mark IA fuel irradiated to an average burnup of 3,000 megawatt-days per metric ton uranium and assuming a 10-year cooling time since removal from the reactor. The 10-year cooling time is conservative because the Hanford N Reactor was last operated in 1987 and SNF of this type is expected to be at least 10 years old by the time shipments would begin. Table I-21 shows the radionuclide inventory used to represent Hanford N-Reactor SNF.

Most of the graphite SNF under the responsibility of the DOE is from the Fort St. Vrain reactor owned by Public Service of Colorado. Some Fort St. Vrain SNF is already in storage at the Idaho National Engineering Laboratory, but most SNF is still in storage at the Fort St. Vrain site awaiting transport to a DOE facility. In addition to the Fort St. Vrain SNF, smaller amounts of other graphite SNF are currently in storage at the Idaho National Engineering Laboratory. Characteristics for graphite SNF are, therefore, based on Fort St. Vrain SNF. Table I-22 shows the radionuclide inventory used to represent graphite reactor SNF based on six Fort St. Vrain fuel blocks irradiated to an average burnup of 70,000 megawatt-days per metric ton uranium and assuming a cooling time of 1,600 days (Block 1993). The 1,600-day (about 4.3 years) cooling time is conservative because the Fort St. Vrain reactor was shut down in August 1989, and shipments will not be made before June 1995.

SNF from various commercial reactors is currently in storage at various DOE sites, mostly at the Idaho National Engineering Laboratory. Special-case commercial SNF currently in storage at the Idaho National Engineering Laboratory includes core debris from the damaged Three Mile Island Unit 2 reactor. Commercial SNF includes both boiling water reactor and pressurized water reactor SNF. Pressurized water reactor SNF was chosen as most representative because it is most prevalent and typically contains the highest levels of radioactivity (Fischer et al. 1987). Table I-23 shows the radionuclide inventory used to represent commercial SNF based on one pressurized water reactor fuel assembly irradiated to an average burnup of 33,000 megawatt-days per metric ton uranium and assuming a cooling time of 10 years (Fischer et al. 1987). The 10-year cooling time is conservative because the majority of special-case commercial SNF currently in storage at DOE sites will be at least 10 years old by June 1995.

Table I-20. Radionuclide inventory for representative Savannah River Site production reactor spent nuclear fuel.(a)

Isotope	Inventory (curie)
H-3	1.21 X 10^1
Kr-85	2.62 X 10^2
Sr-90	3.21 X 10^3
Y-90	3.21 X 10^3
Ru-106	7.64 X 10^0
Rh-106	7.64 X 10^0
Cs-134	1.48 X 10^2
Cs-137	3.18 X 10^3
Ba-137m	3.01 X 10^3
Ce-144	1.51 X 10^1
Pr-144	1.51 X 10^1
Pm-147	1.07 X 10^2
Pu-238	6.84 X 10^1
Pu-239	7.69 X 10^-1
Pu-240	5.23 X 10^-1
Pu-241	9.52 X 10^1
Am-241	1.97 X 10^0

a. Inventory based on one fuel assembly from a tritium producing charge, 10 years cooling out of reactor.

Table I-21. Radionuclide inventory for representative Hanford N-Reactor spent nuclear fuel.

Isotope	Inventory (curie per metric ton uranium)
H-3	3.09 X 10^1
Kr-85	5.89 X 10^2
Sr-90	6.80 X 10^3
Y-90	6.80 X 10^3
Ru-106	5.56 X 10^1
Sb-125	1.26 X 10^2
Cs-134	1.49 X 10^2
Cs-137	8.39 X 10^3
Ba-137m	7.94 X 10^3
Ce-144	3.24 X 10^1
Pm-147	2.24 X 10^3
Pu-238	5.06 X 10^1
Pu-239	1.10 X 10^2
Pu-240	5.97 X 10^1
Pu-241	4.47 X 10^3
Am-241	9.33 X 10^1

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a. Inventory based on Mark IA N-Reactor fuel, 10 years cooling out of reactor, average burnup 3,000 megawatt-days per metric ton uranium.

Table I-22. Radionuclide inventory for representative graphite reactor spent nuclear fuel.

Isotope	Inventory (curie)
Kr-85	2.35 X 10^3
Sr-90	1.57 X 10^4
Rh-106	5.94 X 10^2
Ru-106	5.94 X 10^2
Sb-125	3.36 X 10^2
Cs-134	7.45 X 10^3
Cs-137	1.65 X 10^4
Ce-144	3.77 X 10^3
Pr-144	3.77 X 10^3
Pm-147	6.32 X 10^3
Sm-151	5.4 X 10^1
Eu-154	9.48 X 10^2
Eu-155	1.38 X 10^2
U-232	1.8 X 10^1
U-233	2.4 X 10^1
Pu-238	4.20 X 10^2
Pu-241	3.06 X 10^2

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a. Inventory based on six Fort St. Vrain fuel blocks, 1600 days cooling out of reactor, average burnup of 70,000 megawatt-days per metric ton uranium.

Table I-23. Radionuclide inventory for representative special-case commercial spent nuclear fuel.

Isotope	Inventory (curie)
Co-60	6.28 X 10^2
Kr-85	2.23 X 10^3
Sr-90	2.75 X 10^4
Y-90	2.73 X 10^4
Ru-106	2.52 X 10^2
I-129	1.48 X 10^-2
Cs-134	4.85 X 10^3
Cs-137	3.85 X 10^4
Ba-137m	3.62 X 10^4
Ce-144	9.01 X 10^1

Pu-238	1.36 X 10^3
Pu-239	1.67 X 10^2
Pu-240	2.06 X 10^2
Pu-241	4.32 X 10^4
Am-241	9.66 X 10^2
Cm-244	6.90 X 10^2

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a. Inventory based on one pressurized water reactor fuel assembly, 10 years cooling out of reactor, average burnup 33,000 megawatt-days per metric ton uranium.

Domestic university research and test reactors represent a variety of reactor types and fuel designs. High-enriched training, research, and isotope reactor (TRIGA) SNF was chosen as representative of university reactor SNF because it is one of the largest groups of university SNF to be transported and because it is a rod-type fuel that would be expected to have the highest release of fission products under severe accident conditions. The radionuclide inventory of high-enriched TRIGA fuel was calculated using the ORIGEN2 computer code (Croff 1980) assuming a 17-year reactor operating cycle based on operation of the Texas A&M University TRIGA reactor. To facilitate the modeling of accident consequences, the radionuclide inventory generated by the ORIGEN2 program was truncated to eliminate minor contributors to dose. The radionuclides eliminated accounted for less than 1 percent of the total dose. Additional details are available in Enyeart (1995). Table I-24 shows the radionuclide inventory representative of university research and test reactor SNF based on 19 TRIGA fuel rods irradiated to an average burnup of 20.2 percent and assuming a cooling time of 1 year.

DOE research and test reactors are also represented by a variety of reactor types and fuel designs. Experimental Breeder Reactor-II Mark-V SNF was chosen as representative of DOE research and test reactors because the reactor at the Idaho National Engineering Laboratory is one of the few DOE research and test reactors still operating. Mark-V fuel is the current generation of Experimental Breeder Reactor-II fuel types. The high plutonium content of Mark-V fuel increases the relative hazard of the radionuclide inventory compared to other DOE SNF types. The radionuclide inventory of the Mark-V fuel was calculated using the ORIGEN2 computer code assuming a typical Experimental Breeder Reactor-II operating cycle. To facilitate the modeling of accident consequences, the radionuclide inventory generated by the ORIGEN2 program was truncated to eliminate minor contributors to dose. The radionuclides eliminated accounted for less than 1 percent of the total dose. Additional details are available in Enyeart (1995). Table I-25 shows the radionuclide inventory representative of DOE research and test reactor SNF based on one Mark-V fuel assembly irradiated to a burnup of 7.88 percent and assuming a cooling time of 1 year.

Foreign research and test reactors use a number of different fuel designs. DOE has evaluated the characteristics of foreign research reactor SNF types in a separate EIS on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel. Based on this evaluation, a shipment of 40 TRIGA-type SNF elements was determined to result in the highest potential release of radioactivity in the event of an accident. To provide a bounding analysis for this EIS, foreign TRIGA-type SNF was selected as representative of all foreign research reactor SNF. To facilitate the modeling of accident consequences, the radionuclide inventory generated by the ORIGEN2 program was truncated to eliminate minor contributors to dose. The radionuclides eliminated accounted for less than 1 percent of the total dose. The radionuclide inventory of a single shipping cask, shown in Table I-26, is based on a reactor operating period of 3 years, with a burnup of 31 grams of uranium-235 per fuel element, followed by a cooling period of 1 year.

Table I-24. Radionuclide inventory for representative university research/test reactor spent nuclear fuel.

Isotope	Inventory (curie)	Isotope	Inventory (curie)
H-3	3.25 X 10^0	Cs-137	9.72 X 10^2
Kr-85	8.60 X 10^1	Ba-137M	9.20 X 10^2
Sr-89	4.28 X 10^1	Ce-141	3.86 X 10^0
Sr-90	9.30 X 10^2	Ce-144	1.47 X 10^3
Y-90	9.30 X 10^2	Pr-144	1.47 X 10^3
Y-91	9.77 X 10^1	Pm-147	8.81 X 10^2
Zr-95	1.48 X 10^2	U-235	4.00 X 10^-3
Nb-95	3.20 X 10^2	U-236	5.50 X 10^-3
Ru-103	7.47 X 10^0	Pu-238	1.00 X 10^0
Rh-103m	6.74 X 10^0	Pu-239	1.57 X 10^-1
Ru-106	1.36 X 10^2	Pu-240	6.70 X 10^-2
Te-125m	4.11 X 10^0	Pu-241	5.88 X 10^0
Te-127	2.08 X 10^0	Am-241	4.57 X 10^-2
Te-127m	2.12 X 10^0	Cm-242	1.81 X 10^-1
Cs-134	1.10 X 10^2		

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a. Inventory based on 19 TRIGA fuel rods (70 percent enrichment; 122 g/rod uranium-235 beginning-of-life), 1 year cooling out of reactor, 20.2 percent average burnup.

Table I-25. Radionuclide inventory for representative DOE research/test reactor spent nuclear fuel.

Isotope	Inventory (curie per assembly)	Isotope	Inventory (curie per assembly)
H-3	7.98 X 10^0	Te-127	3.32 X 10^1
Mn-54	7.48 X 10^2	Te-129m	1.14 X 10^0
Fe-55	6.12 X 10^2	Cs-134	9.15 X 10^1
Co-58	1.25 X 10^2	Cs-137	1.04 X 10^3
Co-60	3.55 X 10^0	Ba-137m	9.80 X 10^2
Kr-85	9.75 X 10^1	Ce-141	1.49 X 10^1
Sr-89	1.45 X 10^2	Ce-144	7.76 X 10^3
Sr-90	7.23 X 10^2	Pr-144m	1.11 X 10^2
Y-90	7.23 X 10^2	Pr-144	7.76 X 10^3
Y-91	3.67 X 10^2	Pm-147	2.65 X 10^3
Zr-95	7.00 X 10^2	Sm-151	2.91 X 10^1
Nb-95	1.52 X 10^3	Eu-155	1.00 X 10^2
Ru-103	4.88 X 10^1	U-235	2.90 X 10^-3
Rh-103m	4.40 X 10^1	U-236	3.34 X 10^-3
Ru-106	3.65 X 10^3	Pu-238	1.48 X 10^0
Rh-106	3.65 X 10^3	Pu-239	4.05 X 10^1
Sn-123	2.48 X 10^1	Pu-240	3.61 X 10^1
Sb-125	1.21 X 10^2	Pu-241	1.39 X 10^3
Te-125m	2.96 X 10^1	Am-241	4.74 X 10^0
Te-127m	3.37 X 10^1		

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a. Inventory based on EBR-II Mark-V fuel, 1 year cooling out of reactor, total burnup of 317 megawatt-days.

Table I-26. Radionuclide inventory for representative foreign research/test reactor spent nuclear fuel.

Isotope	Inventory (curie)	Isotope	Inventory (curie)
H-3	1.31 X 10^1	Ce-141	6.97 X 10^2
Kr-85	3.63 X 10^2	Ce-144	2.55 X 10^4
Sr-89	2.75 X 10^3	Pr-144	2.55 X 10^4
Sr-90	3.16 X 10^3	Pm-147	7.02 X 10^3
Y-90	3.16 X 10^3	Pm-148m	4.68 X 10^1
Y-91	4.56 X 10^3	Eu-154	4.18 X 10^1
Zr-95	6.48 X 10^3	Eu-155	2.27 X 10^1
Nb-95	1.28 X 10^4	U-234	1.81 X 10^-4
Ru-103	8.44 X 10^2	U-235	7.91 X 10^-3
Rh-103m	8.44 X 10^2	U-238	6.51 X 10^-3
Ru-106	2.54 X 10^3	Pu-238	3.03 X 10^0
Rh-106m	2.54 X 10^3	Pu-239	5.50 X 10^-1
Sn-123	2.71 X 10^1	Pu-240	2.09 X 10^0
Sb-125	1.19 X 10^2	Pu-241	2.13 X 10^2

Te-125m	2.87 X 10^1	Am-241	4.07 X 10^-1
Te-127m	5.57 X 10^1	Am-242m	9.00 X 10^-3
Te-129m	2.31 X 10^1	Am-243	4.38 X 10^-4
Cs-134	1.16 X 10^3	Cm-244	7.14 X 10^-3
Cs-137	3.19 X 10^3	Cm-242	5.25 X 10^0

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a. Inventory based on 40 foreign TRIGA fuel elements, 1 year cooling out of reactor, average burnup of 31 grams uranium-235 per fuel element.

Non-DOE research reactor types are generally similar to domestic university research and test reactors. Therefore, TRIGA reactor SNF was also chosen as representative of non-DOE research reactor SNF.

I-5.2.2 Radioactive Release Characteristics

Radiological consequences were calculated by assigning cask release fractions to each accident severity category for each chemically and physically distinct radioisotope. The release fraction is defined as the fraction of the radioactivity in the cask that could be released from the cask in a given severity of accident. Release fractions vary according to SNF type and the physical/chemical properties of the radioisotopes. Most solid radionuclides in SNF are nonvolatile and are, therefore, relatively nondispersible. Gaseous radionuclides, such as krypton-85, are relatively easy to release if the fuel cladding and cask are compromised.

Representative cask release fractions were developed for each of the representative SNF types. The U.S. Nuclear Regulatory Commission Modal Study developed release fractions for commercial pressurized water reactor SNF. The Modal Study release fractions, shown in Table I-27, are based on best engineering judgment and are conservative for most SNF types. For this analysis, the release fractions recommended in the Modal Study were applied only to commercial pressurized-water reactor SNF and TRIGA SNF, both of which are rod-type fuels. Because of the significant differences in fuel designs and the availability of more appropriate fuel-specific release characterization data, less conservative release fractions were applied to the other representative SNF types.

Release fractions for aluminum fuels (aluminum alloy fuel, aluminum cladding) were based on laboratory measurements of release fractions from aluminum fuels at high temperatures (Shibata et al. 1984) and the U.S. Nuclear Regulatory Commission Modal Study (Fischer et al. 1987). Because of the lower melting point of aluminum compared to metals used in other metallic fuels, the aluminum fuel release fractions are considered bounding for metallic fuels (that is, Savannah River Production Reactor, Hanford N-Reactor, and EBR-II Mark V SNF). Release fractions for the aluminum and other metallic fuel types are listed in Table I-28.

Release fractions for graphite fuels, specifically Fort St. Vrain SNF, were based on engineering analyses. Fort St. Vrain fuel is in the form of carbide particles, encased within a highly retentive four-layer ceramic coating. Stress analysis tests have shown that the fuel particles can withstand stresses well in excess of those that might be encountered in severe accidents. Thermal diffusion across the ceramic barrier under extreme temperature conditions is the only significant mechanism for release of fission products from intact Fort St. Vrain fuel. Fuel particles that have failed during reactor operation (less than 1 percent of the inventory) are vulnerable to vaporization and impact-induced releases of particulates, but volatile fission products would have been released within the extreme thermal environment of the operating reactor. Table I-29 summarizes the release fractions applied to Fort St. Vrain SNF, assuming 1 percent fuel failure during reactor operations.

Table I-27. Release fractions for transportation accidents involving special-case commercial, university, foreign, and non-DOE research reactor spent nuclear fuel types for the U.S. Nuclear Regulatory Commission Modal Study cask response regions.

	Release fractiona				
Cask response region	Inert gas	Iodine	Cesium	Ruthenium	Particulates
R(1,1)	0.0	0.0	0.0	0.0	0.0
R(1,2),R(1,3)	9.9 10-3	7.5 10-5	6.0 10-6	8.1 10-7	6.0 10-8
R(2,1),R(2,2),R(2,3)	3.3 10-2	2.5 10-4	2.0 10-5	2.7 10-6	2.0 10-7
R(1,4),R(2,4),R(3,4)	3.9 10-1	4.3 10-3	2.0 10-4	4.8 10-5	2.0 10-6
R(3,1),R(3,2),R(3,3)	3.3 10-1	2.5 10-3	2.0 10-4	2.7 10-5	2.0 10-6
R(1,5),R(2,5),R(3,5),R(4,5),R(4,1),R(4,2),R(4,3),R(4,4)	6.3 10-1	4.3 10-2	2.0 10-3	4.8 10-4	2.0 10-5

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a. U.S. Nuclear Regulatory Commission Modal Study (Fischer et al. 1987).

Table I-28. Release fractions for transportation accidents involving aluminum and metallic spent nuclear fuel typesa for the U.S. Nuclear Regulatory Commission Modal Study cask response regions.

	Release fractionb				
Cask response region	Inert gas	Iodine	Cesium	Ruthenium	Particulates
R(1,1)	0.0	0.0	0.0	0.0	0.0
R(1,2),R(1,3)	9.9 10^-3	1.1 10^-7	3.0 10^-8	4.1 10^-9	3.0 10^-10
R(2,1),R(2,2),R(2,3)	3.3 10^-2	3.5 10^-7	1.0 10^-7	1.4 10^-8	1.0 10^-9
R(1,4),R(2,4),R(3,4)	3.9 10^-1	6.0 10^-6	1.0 10^-6	2.4 10^-7	1.0 10^-8
R(3,1),R(3,2),R(3,3)	3.3 10^-1	3.5 10^-6	1.0 10^-6	1.4 10^-7	1.0 10^-8
R(1,5),R(2,5),R(3,5)(4,5),R(4,1),R(4,2),R(4,3),R(4,4)	6.3 10^-1	6.0 10^-5	1.0 10^-5	2.4 10^-6	1.0 10^-7

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a. These release fractions are applicable to the following SNF types:
  1. N Reactor
  2. Savannah River Site production reactor
  3. DOE research/test reactor

b. Derived from Shibata et al. (1984) and U.S. Nuclear Regulatory Commission Modal Study (Fischer et al. 1987).

Table I-29. Release fractions for transportation accidents involving graphite spent nuclear fuel for the U.S. Nuclear Regulatory Commission Modal Study cask response regions.

	Release fraction					
Cask response region	Inert gasa	Strontium, ceriumb	Antimonyc	Cesiumb	Ruthenium, rhodiumc	Particulatesd
R(1,1)	0.0	0.0	0.0	0.0	0.0	0.0
R(1,2),R(1,3),R(1,4),R(2,1),R(2,2),R(2,3),R(2,4),R(3,1),R(3,2),R),R(3,4),R(4,1),R(4,2),R(4,3),R(4,4)	5.3 10^-3	3.7 10^-7	1.0 10^-6	2.4 10^-7	7.3 10^-8	1.0 10^-9
R(1,5),R(2,5),R(3,5(4,5)	1.2 10^-2	5.0 10^-6	1.0 10^-6	9.1 10^-6	7.3 10^-8	1.0 10^-9

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a. Thermally induced, from NUREG/CR-0722, Table 40, all fuel (Lorenz et al. 1980).

b. Empirical data from the Fort St. Vrain Final Safety Analysis Report, Rev. 8, Table A.3-1 (PSC no date).

c. Thermally induced semivolatiles from incore failed fuel; 1 percent fuel failure, 100 percent respirable; release fraction from Lorenz et al. (1980).

d. Impact induced nonvolatiles, 1 percent incore failed fuel, 5 percent respirable, release fraction of 2 10^-6 from Wilmot (1981).

I-5.3 Results of Calculations

I-5.3.1 Impacts from the No Action Alternative

There are no offsite shipments of DOE, university, foreign, or non-DOE research reactor SNF under this alternative. Consequently, there are no transportation accident impacts. The limited number of naval fuel shipments made under the No Action alternative are covered in Appendix D of Volume 1 of this EIS.

I-5.3.2 Impacts from the Decentralization Alternative

The SNF shipments included under this alternative are those of domestic university, foreign, and non-DOE research reactor SNF to the Idaho National Engineering Laboratory and Savannah River Site. Naval fuel shipments made under different options of the Decentralization alternative are covered in Appendix D of Volume 1 of this EIS. Shipments are expected to be made by truck, but the impact analysis also assessed transportation by rail. The same shipping cask was assumed to be used for both truck and rail shipments, and a single shipping cask was assumed for each shipment.

The cumulative accident risk for transportation by truck was calculated to be 0.0009 latent cancer fatality and 0.15 traffic fatality. The cumulative accident risk measures the total impact of transportation accidents over the entire shipment campaign (1995 to 2035). The cumulative accident risk for transportation by rail was calculated to be 0.0003 latent cancer fatality and 0.21 traffic fatality. Table I-30 summarizes the transportation accident risks for the Decentralization alternative.

As shown in Table I-31, the maximum reasonably foreseeable transportation accident has a probability of occurrence of about 1.6 10-7 per year for a suburban population zone. Under normal (neutral) weather conditions, the total population dose is estimated to be about 14 person-rem, which would be expected to result in less than one latent cancer fatality in the exposed population. For comparison, the same population would be expected to experience about 100,000 latent fatal cancers from other causes. The probability of this accident occurring in an urban population zone, or occurring under stable weather conditions in any population zone, is less than 1 10-7 per year.

I-5.3.3 Impacts from the 1992/1993 Planning Basis Alternative

This alternative includes the transport of five types of SNF. It assumes that the Fort St. Vrain SNF currently in storage in Colorado is transported to the Idaho National Engineering Laboratory. Likewise, special-case commercial SNF currently stored at West Valley is transported to the Idaho National Engineering Laboratory. DOE research and test reactor SNF is transported to either the Idaho National Engineering Laboratory or Savannah River Site, with most going to the Idaho National Engineering Laboratory. Shipments of university, foreign, and non-DOE research reactor SNF are split between the Idaho National Engineering Laboratory and the Savannah River Site. Shipments could be by truck or rail, so the analysis addresses the two extremes of all shipments by truck

Table I-30. SNF transportation accident risks for the Decentralization alternative (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent cancer fatalities(a)	Traffic fatalities(b)
Truck	1.7	0.0009	0.15
Rail	0.57	0.0003	0.21

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-31. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under the Decentralization alternative (1995 to 2035).

Alternative: Decentralization
Maximum reasonably foreseeable accident: University research reactor SNF shipment by rail
Population zone: Suburbana
Maximum reasonably foreseeable accident probability: 1.6 10-7 per year with neutral meteorology, less than 1 X 10^-7 per year with stable meteorology

Doses and health effects	Transport mode	Population		Maximum exposed individual	
		Neutral(b)	Stable(c)	Neutral(b)	Stable(c)
Dose	Rail	14 person-rem	(e)	0.032 rem	(e)
Latent cancer fatalities(d)	Rail	0.007	(e)	1.6 X 10^-5	(e)

a. The maximum reasonably foreseeable accident occurs in a suburban population zone. The probability of the accident occurring in an urban population zone is less than 1 10-7 per year. In a rural population zone, the dose would be approximately 9 percent of the suburban population dose.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of latent fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5 10-4 fatal cancers per person-rem (ICRP 1991).

e. Consequences not developed for accidents with probabilities less than 1 10-7 per year.

or all shipments by rail.

The cumulative accident risk for transportation by truck was calculated to be 0.0009 latent cancer fatality and 0.19 traffic fatality. The cumulative accident risk measures the total impact of transportation accidents over the entire shipment campaign (1995 to 2035). The cumulative accident risk for transportation by rail was calculated to be 0.0003 latent cancer fatality and 0.22 traffic fatality. Table I-32 summarizes the transportation accident risks for the 1992/1993 Planning Basis alternative.

The maximum reasonably foreseeable transportation accident involves a rail shipment of special-case commercial SNF. The accident has a probability of occurrence of about 2.0 X 10^-7 per year for a suburban population zone. Under normal (neutral) weather conditions, the total population dose is estimated to be about 13,000 person-rem (average dose of 26 millirem per person), which could result in an estimated seven latent fatal cancers in the exposed population. For comparison, the same population would be expected to experience about 100,000 latent fatal cancers from other causes. The probability of this accident occurring in an urban population zone, or occurring under stable weather conditions in any population zone, is less than 1 X 10^-7 per year. Table I-33 summarizes the doses and health effects from the maximum reasonably foreseeable consequence assessment.

I.5.3.4 Impacts from the Regionalization Alternative

This alternative includes Regionalization 4A (by fuel type) and Regionalization 4B (by geography). Under Regionalization by Fuel Type, the same SNF types are transported as in the 1992/1993 Planning Basis alternative with differences occurring in the destinations of some SNF based on fuel type. DOE research and test reactor SNF is transported to either the Idaho National Engineering Laboratory or the Savannah River Site, with most SNF going to the Idaho National Engineering Laboratory. Graphite-type and special-case commercial SNF is transported to the Idaho National Engineering Laboratory. As with the 1992/1993 Planning Basis alternative, shipments could be by truck or rail, and the analysis evaluates impacts assuming either of two extremes: all shipments by truck or all shipments by rail.

Under Regionalization by Fuel Type, the cumulative accident risk for transportation by truck was calculated to be 0.0010 latent cancer fatality and 0.26 traffic fatality. The cumulative accident risk measures the total impact of transportation accidents over the entire shipment campaign (1995 to 2035). The cumulative accident risk for transportation by rail was calculated to be 0.0003 latent

Table I-32. SNF transportation accident risks for the 1992/1993 Planning Basis alternative (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent cancer fatalities[a]	Traffic fatalities[b]
Truck	1.9	0.0009	0.19
Rail	0.61	0.0003	0.22

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-33. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under the 1992/1993 Planning Basis alternative (1995 to 2035).

Alternative: 1992/1993 Planning Basis

Maximum reasonably foreseeable accident: Special-case commercial SNF shipment by rail
Population zone: Suburbana
Maximum reasonably foreseeable accident probability: 2.0 10-7 per year with neutral meteorology, less than 1.0 X 10^-7 per year with stable meteorology

Doses and health effects	Transport mode	Population		Maximum exposed individual	
		Neutral(b)	Stable(c)	Neutral(b)	Stable(c)
Dose	Rail	13,000 person-rem	(e)	54 rem	(e)
Latent cancer fatalities(d)	Rail	7	(e)	0.027	(e)

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a. The maximum reasonably foreseeable accident occurs in a suburban population zone. The probability of the accident occurring in an urban population zone is less than 1 X 10^-7 per year. In a rural population zone, the dose would be approximately 3 percent of the suburban population dose.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5 X 10^-4 fatal cancers per person-rem (ICRP 1991).

e. Consequences not developed for accidents with probabilities less than 1 X 10^-7 per year.

cancer fatality and 0.25 traffic fatality. Table I-34 summarizes the transportation accident risk for the Regionalization by Fuel Type.

As in the 1992/1993 Planning Basis alternative, the maximum reasonably foreseeable transportation accident involves a rail shipment of special-case commercial SNF. The accident has a probability of occurrence of about 2.8 10-7 per year for a suburban population zone. The consequences under normal (neutral) weather conditions are the same as those described under the 1992/1993 Planning Basis alternative. Table I-35 summarizes the doses and health effects from the maximum reasonably foreseeable consequence assessment.

The maximum reasonably foreseeable accident under stable weather conditions has a probability less than 1 X 10^-7 per year for all population zones except rural. A total population dose of 3,500 person-rem was estimated for the rural population zone (average dose of 2 rem per person), which could result in an estimated two latent fatal cancers in the exposed population. For comparison, the same population would be expected to experience about 350 latent fatal cancers from other causes.

The Regionalization by Geography alternative contains six separate alternatives, and the transportation impacts of each option have been analyzed for comparison. Under this alternative, the same SNF types are transported as under the 1992/1993 Planning Basis alternative with differences occurring in the destinations of the SNF based on geographical considerations. Non-Navy SNF originating from western United States locations or points of entry would be transported to the Idaho National Engineering Laboratory, Hanford Site, or the Nevada Test Site. Non-Navy SNF originating from eastern United States locations or points of entry would be transported to the Savannah River Site or the Oak Ridge Reservation.

Navy SNF would not be split on an east-west basis because the Navy would operate a facility for examining naval SNF at only one of the DOE sites.

Cumulative accident risks for transportation by truck range from 0.0009 latent cancer fatality and 0.21 traffic fatality for Regionalization at the Idaho National Engineering Laboratory and the Savannah River Site, to 0.0011 latent cancer fatality and 0.39 traffic fatality for Regionalization at the Nevada Test Site and the Oak Ridge Reservation. Cumulative accident risks for transportation by rail range from 0.0002 latent cancer fatality and 0.21 traffic fatality for Regionalization at the Idaho National Engineering Laboratory and the Oak Ridge Reservation to 0.0003 latent cancer fatality and 0.30 traffic fatality for Regionalization at the Nevada Test Site and the Savannah River Site.

As in Regionalization by Fuel Type, the maximum reasonably foreseeable transportation accident involves a rail shipment of special-case commercial SNF. The consequences of the maximum reasonably foreseeable accident are the same for each of the six Regionalization by Geography alternatives. The maximum reasonably foreseeable accident under neutral weather conditions occurs in a suburban population zone because the accident probability for an urban

Table I-34. SNF transportation accident risks for Regionalization by Fuel Type (1995-2035).

Transport mode	Dose risk (person-rem)	Latent cancer fatalities(a)	Traffic fatalities(b)
Truck	2.0	0.0010	0.26
Rail	0.65	0.0003	0.25

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-35. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under Regionalization by Fuel Type (1995 to 2035).

Alternative: Regionalization by Fuel Type
Maximum reasonably foreseeable accident: Special-case commercial SNF shipment by rail
Population zone: Suburban (neutral) and rural (stable)a
Maximum reasonably foreseeable accident probability: 2.8 X 10^-7 per year with neutral meteorology; 1.1 X 10^-7 per year with stable meteorology

Doses and health effects	Transport mode	Population		Maximum exposed individual	
		Neutral(b)	Stable(c)	Neutral(b)	Stable(c)
Dose	Rail	13,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer fatalities(d)	Rail	7	2	0.027	0.09

a. The maximum reasonably foreseeable accident occurs in a suburban population zone under neutral weather conditions. The accident probability is less than 1 X 10^-7 per year under stable weather conditions, except in a rural population zone. For urban population zones, the accident probability is less than 1 X 10^-7 per year for both neutral and stable weather conditions.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5 X 10^-4 fatal cancers per person-rem (ICRP 1991).

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population zone is less than 1 10-7 per year. The total population dose is estimated to be about 13,000 person-rem (average dose of 26 millirem per person), which could result in an estimated seven latent fatal cancers in the exposed population. For comparison, the same population would be expected to experience about 100,000 latent fatal cancers from other causes.

The probability of the maximum reasonably foreseeable transportation accident varies slightly among the six Regionalization by Geography alternatives. The maximum reasonably foreseeable accident in a suburban population zone has an estimated probability of occurrence ranging from about 2.7 X 10^-7 per year for Regionalization at the Hanford Site and Savannah River Site, to about 3.7 X 10^-7 per year for Regionalization at the Nevada Test Site and Savannah River Site. The maximum reasonably foreseeable accident in a rural population zone has an estimated probability of occurrence ranging from about 1.5 X 10^-7 per year for Regionalization at the Hanford Site and Savannah River Site, to about 3.3 X 10^-7 per year for Regionalization at the Nevada Test Site and Oak Ridge Reservation.

Tables I-36 through I-47 summarize the doses and health effects from the accident risk assessment and the maximum reasonably foreseeable consequence assessment for each of the Regionalization by Geography alternatives.

I-5.3.5 Impacts from the Centralization Alternatives

The impacts from centralization at the Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, Oak Ridge Reservation, and the Nevada Test Site are presented in this section.

I-5.3.5.1 Centralization at the Hanford Site. Under this alternative, SNF currently stored at

other DOE sites, Fort St. Vrain, university, foreign, and non-DOE research reactors is eventually transported to the Hanford Site. The analysis evaluates impacts assuming either all shipments by truck or all shipments by rail.

The cumulative accident risk for transportation by truck was calculated to be 0.0050 latent cancer fatality and 0.57 traffic fatality. The cumulative accident risk measures the total impact of transportation accidents over the entire shipment campaign (1995 to 2035). The cumulative accident risk for transportation by rail was calculated to be 0.0013 latent cancer fatality and 0.52 traffic fatality. Table I-48 summarizes the transportation accident risks for the Centralization at the Hanford Site alternative.

As in the 1992/1993 Planning Basis and Regionalization alternatives, the maximum reasonably foreseeable transportation accident involves a rail shipment of special-case commercial SNF. The accident has a probability of occurrence of about 5.1 10-7 per year under neutral (normal) weather conditions and 3.6 X 10^-7 per year under stable (worst-case) weather conditions. The consequences are the same as those described under the Regionalization by Geography alternative. Table I-49

Table I-36. SNF transportation accident risks for Regionalization by Geography (Idaho National

Engineering Laboratory and Savannah River Site) (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent cancer fatalities(a)	Traffic fatalities(b)
Truck	1.7	0.0009	0.21
Rail	0.59	0.0003	0.22

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a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-37. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under Regionalization by Geography (Idaho National Engineering Laboratory and Savannah River Site) (1995 to 2035).

Alternative: Regionalization by Geography (INEL & SRS)
Maximum reasonably foreseeable accident: Special-case commercial SNF shipment by rail
Population zone: Suburban (neutral) and rural (stable)(a)
Maximum reasonably foreseeable accident probability: 3.0 X 10^-7 per year with neutral meteorology, 1.9 X 10^-7 per year with stable meteorology

Doses and health effects	Transport mode	Population(a)		Maximum exposed individual	
		Neutral(b)	Stable(c)	Neutral(b)	Stable(c)
Dose	Rail	13,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer fatalitiesd	Rail	7	2	0.027	0.09

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a. The maximum reasonably foreseeable accident occurs in a suburban population zone under neutral weather conditions. The accident probability is less than 1 10-7 per year under stable weather conditions, except in a rural population zone. For urban population zones, the accident probability is less than 1 X 10^-7 per year for both neutral and stable weather conditions.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5 X 10^-4 fatal cancers per person-rem (ICRP 1991).

Table I-38. SNF transportation accident risks for Regionalization by Geography (Idaho National Engineering Laboratory and Oak Ridge Reservation) (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent cancer fatalities(a)	Traffic fatalities(b)

Truck	1.8	0.0009	0.22
Rail	0.40	0.0002	0.21

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a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-39. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under Regionalization by Geography (Idaho National Engineering Laboratory and Oak Ridge Reservation) (1995 to 2035).

Alternative: Regionalization by Geography (INEL & ORR)
Maximum reasonably foreseeable accident: Special-case commercial SNF shipment by rail
Population zone: Suburban (neutral) and rural (stable)a
Maximum reasonably foreseeable accident probability: 3.0 X 10^-7 per year with neutral meteorology, 2.0 X 10^-7 per year with stable meteorology

Doses and health effects	Transport mode	Population(a)		Maximum exposed individual	
		Neutral(b)	Stable(c)	Neutral(b)	Stable(c)
Dose	Rail	13,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer fatalities(d)	Rail	7	2	0.027	0.09

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a. The maximum reasonably foreseeable accident occurs in a suburban population zone under neutral weather conditions. The accident probability is less than 1 X 10^-7 per year under stable weather conditions, except in a rural population zone. For urban population zones, the accident probability is less than 1 X 10^-7 per year for both neutral and stable weather conditions.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5 X 10^-4 fatal cancers per person-rem (ICRP 1991).

Table I-40. SNF transportation accident risks for Regionalization by Geography (Hanford Site and Savannah River Site) (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent cancer fatalities(a)	Traffic fatalities(b)
Truck	1.8	0.0009	0.24
Rail	0.62	0.0003	0.22

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a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-41. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under Regionalization by Geography (Hanford Site and Savannah River Site) (1995 to 2035).

Alternative: Regionalization by Geography (HS & SRS)
Maximum reasonably foreseeable accident: Special-case commercial SNF shipment by rail
Population zone: Suburban (neutral) and rural (stable)a
Maximum reasonably foreseeable accident probability: 2.7 10-7 per year with neutral meteorology, 1.5 X 10^-7 per year with stable meteorology

Doses and health effects	Transport mode	Population(a)		Maximum exposed individual	
		Neutral(b)	Stable(c)	Neutral(b)	Stable(c)
Dose	Rail	13,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer fatalitiesd	Rail	7	2	0.027	0.09

a. The maximum reasonably foreseeable accident occurs in a suburban population zone under neutral weather conditions. The accident probability is less than 1 10-7 per year under stable weather conditions, except in a rural population zone. For urban population zones, the accident probability is less than 1 X 10^-7 per year for both neutral and stable weather conditions.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5 X 10^-4 fatal cancers per person-rem (ICRP 1991).

Table I-42. SNF transportation accident risks for Regionalization by Geography (Hanford Site and Oak Ridge Reservation) (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent cancer fatalities(a)	Traffic fatalities(b)
Truck	1.9	0.0009	0.24
Rail	0.43	0.0002	0.21

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-43. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under Regionalization by Geography (Hanford Site and Oak Ridge Reservation) (1995 to 2035).

Alternative: Regionalization by Geography (HS & ORR)
Maximum reasonably foreseeable accident: Special-case commercial SNF shipment by rail

Population zone: Suburban (neutral) and rural (stable)a
Maximum reasonably foreseeable accident probability: 2.7 10-7 per year with neutral meteorology, 1.5 X 10^-7 per year with stable meteorology

Doses and health effects	Transport mode	Population(a)		Maximum exposed individual	
		Neutral(b)	Stable(c)	Neutral(b)	Stable(c)
Dose	Rail	13,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer fatalitiesd	Rail	7	2	0.027	0.09

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a. The maximum reasonably foreseeable accident occurs in a suburban population zone under neutral weather conditions. The accident probability is less than 1 X 10^-7 per year under stable weather conditions, except in a rural population zone. For urban population zones, the accident probability is less than 1 X 10^-7 per year for both neutral and stable weather conditions.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5 X 10^-4 fatal cancers per person-rem (ICRP 1991).

Table I-44. SNF transportation accident risks for Regionalization by Geography (Nevada Test Site and Savannah River Site) (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent cancer fatalities(a)	Traffic fatalities(b)
Truck	2.0	0.0010	0.38
Rail	0.61	0.0003	0.30

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a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-45. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under Regionalization by Geography (Nevada Test Site and Savannah River Site) (1995 to 2035).

Alternative: Regionalization by Geography (NTS & SRS)
Maximum reasonably foreseeable accident: Special-case commercial SNF shipment by rail
Population zone: Suburban (neutral) and rural (stable)a
Maximum reasonably foreseeable accident probability: 3.7 X 10^-7 per year with neutral meteorology, 3.3 X 10^-7 per year with stable meteorology

Doses and health effects	Transport mode	Population(a)	Maximum exposed individual

		Neutral(b)	Stable(c)	Neutral(b)	Stable(c)
Dose	Rail	13,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer fatalitiesd	Rail	7	2	0.027	0.09

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a. The maximum reasonably foreseeable accident occurs in a suburban population zone under neutral weather conditions. The accident probability is less than 1 10-7 per year under stable weather conditions, except in a rural population zone. For urban population zones, the accident probability is less than 1 X 10^-7 per year for both neutral and stable weather conditions.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5 X 10^-4 fatal cancers per person-rem (ICRP 1991).

Table I-46. SNF transportation accident risks for Regionalization by Geography (Nevada Test Site and Oak Ridge Reservation) (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent cancer fatalities(a)	Traffic fatalities(b)
Truck	2.1	0.0011	0.39
Rail	0.42	0.0002	0.30

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a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-47. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under Regionalization by Geography (Nevada Test Site and Oak Ridge Reservation) (1995 to 2035).

Alternative: Regionalization by Geography (NTS & ORR)
Maximum reasonably foreseeable accident: Special-case commercial SNF shipment by rail
Population zone: Suburban (neutral) and rural (stable)(a)
Maximum reasonably foreseeable accident probability: 3.6 X 10^-7 per year with neutral meteorology, 3.3 X 10^-7 per year with stable meteorology

Doses and health effects	Transport mode	Population(a)		Maximum exposed individual(k)	
		Neutral(b)	Stable(c)	Neutral(b)	Stable(c)
Dose	Rail	13,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer fatalitiesd	Rail	7	2	0.027	

0.09

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a. The maximum reasonably foreseeable accident occurs in a suburban population zone under neutral weather conditions. The accident probability is less than 1 X 10^-7 per year under stable weather conditions, except in a rural population zone. For urban population zones, the accident probability is less than 1 X 10^-7 per year for both neutral and stable weather conditions.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5 X 10^-4 fatal cancers per person-rem (ICRP 1991).

Table I-48. SNF transportation accident risks for the Centralization at the Hanford Site alternative (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent cancer fatalities(a)	Traffic fatalities(b)
Truck	9.9	0.0050	0.57
Rail	2.5	0.0013	0.52

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a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-49. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under the Centralization at the Hanford Site alternative (1995 to 2035).

Alternative: Centralization at the Hanford Site
Maximum reasonably foreseeable accident: Special-case commercial SNF shipment by rail
Population zone: Suburban (neutral) and Rural (stable)a
Maximum reasonably foreseeable accident probability: 5.1 X 10^-7 per year with neutral meteorology, 3.6 X 10^-7 per year with stable meteorology

Doses and health effects	Transport mode	Population(a)		Maximum exposed individual	
		Neutral(b)	Stable(c)	Neutral(b)	Stable(c)
Dose	Rail	13,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer fatalitiesd	Rail	7	2	0.027	0.09

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a. The maximum reasonably foreseeable accident occurs in a suburban population zone under neutral weather conditions. The accident probability is less than 1 X 10^-7 per year under stable weather conditions, except in a rural population zone. For urban population zones, the accident probability is less than 1 X 10^-7 per year for both neutral and stable weather conditions.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less

atmospheric
dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as
a result of the radiation dose; for the maximally exposed individual, results express the probability of
contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5 X 10^-4 fatal cancers
per person-rem (ICRP 1991).
summarizes the doses and health effects from the maximum reasonably foreseeable consequence assessment.

I-5.3.5.2 Centralization at the Idaho National Engineering Laboratory. Under this

alternative, all SNF currently stored at other DOE sites, Fort St. Vrain, and university, foreign, and non-DOE research reactors is eventually transported to the Idaho National Engineering Laboratory. The analysis evaluates impacts assuming either all shipments by truck or all shipments by rail.

The cumulative accident risk for transportation by truck was calculated to be 0.0048 latent cancer fatality and 0.49 traffic fatality. The cumulative accident risk measures the total impact of transportation accidents over the entire shipment campaign (1995 to 2035). The cumulative accident risk for transportation by rail was calculated to be 0.0012 latent cancer fatality and 0.44 traffic fatality. Table I-50 summarizes the transportation accident risks for the Centralization at the Idaho National Engineering Laboratory alternative.

As in the 1992/1993 Planning Basis and Regionalization 4A and 4B alternatives, the maximum reasonably foreseeable transportation accident involves a rail shipment of special-case commercial SNF. The accident has a probability of occurring of about 4.7 X 10^-7 per year under neutral (normal) weather conditions and about 3.3 X 10^-7 per year under stable (worst-case) weather conditions. The consequences are the same as those described under Regionalization by Geography alternative. Table I-51 summarizes the doses and health effects from the maximum reasonably foreseeable consequence assessment.

I-5.3.5.3 Centralization at Savannah River Site. Under this alternative, SNF currently stored

at other DOE sites, Fort St. Vrain, university, foreign, and non-DOE research reactors is eventually transported to the Savannah River Site. The analysis evaluates impacts assuming either all shipments by truck or all shipments by rail.

The cumulative accident risk for transportation by truck was calculated to be 0.0016 latent cancer fatality and 0.84 traffic fatality. The cumulative accident risk measures the total impact of transportation accidents over the entire shipment campaign (1995 to 2035). The cumulative accident risk for transportation by rail was calculated to be 0.0004 latent cancer fatality and 0.49 traffic fatality. Table I-52 summarizes the transportation accident risks for the Centralization at Savannah River Site alternative.

As in the 1992/1993 Planning Basis and Regionalization alternatives, the maximum reasonably foreseeable transportation accident involves a rail shipment of special-case commercial SNF. The maximum reasonably foreseeable accident under neutral (normal) weather conditions occurs in an urban population zone and has a probability of occurrence of about 1.7 X 10^-7 per year. A total population dose of 72,000 person-rem was estimated (average dose of 27 millirem per person), which

Table I-50. SNF transportation accident risks for the Centralization at the Idaho National Engineering Laboratory alternative (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent cancer fatalities(a)	Traffic fatalities(b)

Truck	9.5	0.0048	0.49
Rail	2.4	0.0012	0.44

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-51. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under the Centralization at the Idaho National Engineering Laboratory alternative (1995 to 2035).

Alternative: Centralization at the Idaho National Engineering Laboratory
Maximum reasonably foreseeable accident: Special-case commercial SNF shipment by rail
Population zone: Suburban (neutral) and rural (stable)a
Maximum reasonably foreseeable accident probability: 4.7 X 10^-7 per year with neutral meteorology, 3.3 X 10^-7 per year with stable meteorology

Doses and health effects	Transport mode	Population(a)		Maximum exposed individual	
		Neutral(b)	Stable(c)	Neutral(b)	Stable(c)
Dose	Rail	13,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer facilitiesd	Rail	7	2	0.027	0.09

a. The maximum reasonably foreseeable accident occurs in a suburban population zone under neutral weather conditions. The accident probability is less than 1 X 10^-7 per year under stable weather conditions, except in a rural population zone. For urban population zones, the accident probability is less than 1 X 10^-7 per year for both neutral and stable weather conditions.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5 X 10^-4 fatal cancers per person-rem (ICRP 1991).

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could result in an estimated 36 latent cancer fatalities. For comparison, the same population would be expected to experience about 540,000 latent cancer fatalities from other causes.

The maximum reasonably foreseeable accident under stable (worst-case) weather conditions occurs in a suburban population zone and has a probability of occurring of about 1.2 10-7 per year. A total population dose of 110,000 person-rem was estimated (average dose of 0.53 rem per person), which could result in an estimated 55 latent cancer fatalities. For comparison, the same population would be expected to experience about 42,000 latent cancer fatalities from other causes.

Table I-53 summarizes the doses and health effects from the maximum reasonably foreseeable consequence assessment.

I-5.3.5.4 Centralization at Oak Ridge Reservation. Under this alternative, SNF currently

stored at other DOE sites, Fort St. Vrain, university, foreign, and non-DOE research reactors is eventually transported to the Oak Ridge Reservation. The analysis evaluates impacts assuming either all shipments by truck or all shipments by rail.

The cumulative accident risk for transportation by truck was calculated to be 0.0014 latent cancer fatality and 0.78 traffic fatality. The cumulative accident risk measures the total impact of transportation accidents over the entire shipment campaign (1995 to 2035). The cumulative accident risk for transportation by rail was calculated to be 0.0003 latent cancer fatality and 0.43 traffic fatality. Table I-54 summarizes the transportation accident risks for the Centralization at Oak Ridge Reservation alternative.

As in the 1992/1993 Planning Basis and Regionalization alternatives, the maximum reasonably foreseeable transportation accident involves a rail shipment of special-case commercial SNF. The maximum reasonably foreseeable accident under neutral (normal) weather conditions occurs in an urban population zone and has a probability of occurring of about 1.1 10-7 per year. The accident consequences are the same as those described for the urban zone accident under the Centralization at Savannah River Site alternative.

The maximum reasonably foreseeable accident under stable (worst-case) weather conditions occurs in a rural population zone and has a probability of occurring of about 5.7 10-7 per year. The accident consequences are the same as those described for the rural zone accident under the Regionalization by Geography alternative.

Table I-55 summarizes the doses and health effects from the maximum reasonably foreseeable consequence assessment.

Table I-52. SNF transportation accident risks for the Centralization at the Savannah River Site alternative (1995 to 2035).

Transport mode	Dose Risk (person-rem)	Latent cancer fatalities(a)	Traffic fatalities(b)
Truck	3.1	0.0016	0.84
Rail	0.80	0.0004	0.49

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-53. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under the Centralization at the Savannah River Site alternative (1995 to 2035).

Alternative: Centralization at the Savannah River Site
Maximum reasonably foreseeable accident: Special-case commercial SNF shipment by rail
Population zone: Urban (neutral) and Suburban (stable)a
Maximum reasonably foreseeable accident probability: 1.7 X 10^-7 per year with neutral meteorology, 1.2 X 10-^7 per year with stable meteorology

Doses and health effects	Transport mode	Population(a)		Maximum exposed individual	
		Neutral(b)	Stable(c)	Neutral(b)	Stable(c)
Dose	Rail	72,000 person-rem	110,000 person-rem	54 rem	180 rem
Latent cancer fatalitiesd	Rail	36	55	0.027	

0.09

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a. The maximum reasonably foreseeable accident occurs in an urban population zone under neutral weather conditions. The probability of the accident in an urban zone under stable weather conditions is less than 1 X 10^-7 per year. The maximum reasonably foreseeable accident for stable weather conditions occurs in a suburban population zone.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5 X 10^-4 fatal cancers per person-rem (ICRP 1991).

Table I-54. SNF transportation accident risks for the Centralization at the Oak Ridge Reservation alternative (1995 to 2035).

Transport mode	Dose Risk (person-rem)	Latent cancer fatalities(a)	Traffic fatalities(b)
Truck	2.8	0.0014	0.78
Rail	0.52	0.0003	0.43

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a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-55. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under the Centralization at the Oak Ridge Reservation alternative (1995 to 2035).

Alternative: Centralization at the Oak Ridge Reservation
Maximum reasonably foreseeable accident: Special-case commercial SNF shipment by rail
Population zone: Urban (neutral) and rural (stable)a
Maximum reasonably foreseeable accident probability: 1.1 X 10^-7 per year with neutral meteorology, 5.7 X 10^-7 per year with stable meteorology

Doses and health effects	Transport mode	Population(a)		Maximum exposed individual	
		Neutral(b)	Stable(c)	Neutral(b)	Stable(c)
Dose	Rail	72,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer fatalities(d)	Rail	36	2	0.027	0.09

a. The maximum reasonably foreseeable accident occurs in an urban population zone under neutral weather conditions. The accident probability under stable weather conditions is less than 1 X 10^-7 per year, except in a rural population zone.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5 X 10^-4 fatal cancers per person-rem (ICRP 1991).

I-5.3.5.5 Centralization at Nevada Test Site. Under this alternative, SNF currently

stored at other DOE sites, Fort St. Vrain, university, foreign, and non-DOE research reactors is eventually transported to the Nevada Test Site. The analysis evaluates impacts assuming either all shipments by truck or all shipments by rail.

The cumulative accident risk for transportation by truck was calculated to be 0.0050 latent cancer fatality and 0.72 traffic fatality. The cumulative accident risk measures the total impact of transportation accidents over the entire shipment campaign (1995 to 2035). The cumulative accident risk for transportation by rail was calculated to be 0.0012 latent cancer fatality and 0.58 traffic fatality. Table I-56 summarizes the transportation accident risks for the Centralization at Nevada Test Site alternative.

As in the 1992/1993 Planning Basis and Regionalization alternatives, the maximum reasonably foreseeable transportation accident involves a rail shipment of special-case commercial SNF. The accident has a probability of occurring of about 1.0 10-7 per year under neutral (normal) weather conditions in a suburban population zone and about 5.0 10-7 per year under stable (worst-case) weather conditions in a rural population zone. The consequences are the same as those described under the Regionalization by Geography alternative. Table I-57 summarizes the doses and health effects from the maximum reasonably foreseeable consequence assessment.

I-5.3.6 Impacts of Using Alternate Points of Entry for Foreign Research Reactor Spent

Nuclear Fuel Shipments

For transportation accident risks (radiological and vehicle-related), shipments from Jacksonville, Florida, to the Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, Oak Ridge Reservation, and Nevada Test Site would yield lower impacts than shipments from Charleston, South Carolina, Galveston, Texas, Hampton Roads, Virginia, Savannah, Georgia, and the Military Ocean Terminal, Sunny Point, North Carolina, to these same sites. Shipments from Wilmington, North Carolina, to the Savannah River Site and Oak Ridge Reservation would also yield lower impacts than shipments from Charleston, South Carolina, Galveston, Texas, Hampton Roads, Virginia, Savannah, Georgia, and the Military Ocean Terminal Sunny Point, North Carolina, to these same sites. Shipments from Wilmington, North Carolina, to the Hanford Site, Idaho National Engineering Laboratory, and Nevada Test Site would yield slightly higher impacts (about 6 percent) than shipments from Charleston, South Carolina, Galveston, Texas, Hampton Roads, Virginia, Savannah, Georgia, and the Military Ocean Terminal, Sunny Point, North Carolina, to these same sites.

Table I-56. SNF transportation accident risks for the Centralization at the Nevada Test Site alternative (1995 to 2035).

Transport mode Dose Risk Latent
Nonradiological

	(person-rem)	cancer fatalities(a)	fatalities(b)
Truck	10.0	0.0050	0.72
Rail	2.4	0.0012	0.58

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a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-57. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under the Centralization at the Nevada Test Site alternative (1995 to 2035).

Alternative: Centralization at the Nevada Test Site
Maximum reasonably foreseeable accident: Special-case commercial SNF shipment by rail
Population zone: Urban (neutral) and Rural (stable)[a]
Maximum reasonably foreseeable accident probability: 1.0 X 10^-7 per year with neutral meteorology, 5.0 X 10^-7 per year with stable meteorology

Doses and health effects	Transport mode	Population(a)		Maximum exposed individual	
		Neutral(b)	Stable(c)	Neutral(b)	Stable(c)
Dose	Rail	72,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer fatalities[d]	Rail	36	2	0.027	0.09

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a. The maximum reasonably foreseeable accident occurs in an urban population zone under neutral weather conditions. The accident probability is less than 1 X 10^-7 per year under stable weather conditions, except in a rural population zone.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5 X 10^-4 fatal cancers per person-rem (ICRP 1991).

I-6 POTENTIAL MITIGATION MEASURES

The possible impacts from transportation associated with the alternatives could be mitigated in a number of different ways. For example, the routes used for truck shipments could be chosen using

U.S. Department of Transportation routing guidelines. These guidelines are designed to reduce the radiological impacts associated with transportation. The guidelines consider as primary factors (a) the radiation exposure from incident-free transport, (b) the risk to general population from an accidental release of radioactive material, and (c) the economic risk from an accidental release of radioactive material. The guidelines consider as secondary factors (a) emergency response effectiveness, (b) evacuation capabilities, (c) location of special facilities such as schools or hospitals, and (d) traffic fatalities and injuries unrelated to the radioactive nature of the cargo.

Impact mitigation is also provided through the use of approved shipping containers. For shipments containing large amounts of radioactivity, such as SNF, Type B containers will be used. These containers are designed to withstand normal transport conditions and hypothetical accident conditions.

If an accident did occur, Federal, state, local, and Tribal authorities are trained in emergency response. For example, the Shoshone-Bannock Tribes, the State of Idaho, Bingham County, Bingham Memorial Hospital, Bannock Regional Medical Center, Pocatello Regional Medical Center, Idaho Power Company, Intermountain Gas Company, and the U.S. Department of Energy participated in a comprehensive, cooperative Transportation Accident Exercise held in Idaho in 1992 (TRANSAX '92).

The U.S. Environmental Protection Agency has developed protective action guides (EPA 1991) and protective actions that are designed to limit doses in the event of a nuclear incident. Use of these guides and actions also mitigates the impacts of transportation accidents involving radioactive material.

I-7 SPENT NUCLEAR FUEL TRANSPORTATION BY BARGE

As an alternative to truck or rail transport of SNF, barge transport of 71 SNF shipments from Brookhaven National Laboratory, located on Long Island, New York, to the Savannah River Site was evaluated. This section summarizes the impacts from transporting the 71 shipments from Brookhaven National Laboratory to the Savannah River Site.

I-7.1 Transportation Routes

Several routing options were evaluated for the barge shipments from Brookhaven National Laboratory to the Savannah River Site:

- Truck transport from Brookhaven National Laboratory to the Shoreham, New York, dock or Port Jefferson, New York. Shoreham and Port Jefferson are both located on Long Island near Brookhaven National Laboratory.
- Barge transport from Shoreham or Port Jefferson, New York, to Hampton Roads, Virginia; the Military Ocean Terminal, Sunny Point, North Carolina; Charleston, South Carolina; Savannah, Georgia; or directly to the Savannah River Site.
- Truck transport from Hampton Roads, Virginia; the Military Ocean Terminal, Sunny Point, North Carolina; Charleston, South Carolina; or Savannah, Georgia to the Savannah River Site.

The HIGHWAY computer code (Johnson et al. 1993a) was used to estimate the truck routes and the INTERLINE computer code (Johnson et al. 1993b) was used to estimate the barge routes. The truck and barge routes are summarized in Pippen (1995).

I-7.2 Incident-Free Transportation

Incident-free transportation assessments were conducted for barge shipments from Brookhaven National Laboratory to the Savannah River Site and included transport by truck, transport by barge, and intermodal transfers (e.g., truck to barge and barge to truck transfers). The methods and data used to estimate the radiological and nonradiological impacts of these shipments are discussed in Pippen (1995).

For barge shipments using the Shoreham, New York, dock as a point of departure from Long Island, the cumulative number of total fatalities (radiological plus nonradiological fatalities) ranged from 0.0048 to 0.0092. The lower number of fatalities was estimated when the barge shipments were made directly to the Savannah River Site. The larger number of fatalities was estimated when the barge shipments were made from Brookhaven National Laboratory to Shoreham, New York, to Hampton Roads, Virginia, to the Savannah River Site.

For barge shipments using Port Jefferson, New York, as a point of departure from Long Island, the cumulative number of total fatalities (radiological plus nonradiological fatalities) ranged from 0.0052 to 0.0093. The lower number of fatalities was estimated when the barge shipments were made directly to the Savannah River Site. The larger number of fatalities was estimated when the barge shipments were made from Brookhaven National Laboratory to Port Jefferson to Hampton Roads, Virginia, to the Savannah River Site.

I-7.3 Transportation Accidents

Transportation accident assessments were conducted for barge shipments from Brookhaven National Laboratory to the Savannah River Site. These assessments included evaluations of accident risks (both radiological risks and traffic fatalities) and accident consequences. The methods and data used to estimate the accident risks and consequences of these shipments are discussed in Pippen (1995).

For barge shipments using the Shoreham, New York, dock as a point of departure from Long Island, the cumulative accident risk (radiological plus nonradiological fatalities) ranged from 0.0011 to 0.0019. The lower number of fatalities was estimated when the barge shipments were made directly to the Savannah River Site. The larger number of fatalities was estimated when the barge shipments were made from Brookhaven National Laboratory to Shoreham, New York, to Hampton Roads, Virginia, to the Savannah River Site.

For barge shipments using Port Jefferson, New York, as a point of departure from Long Island, the cumulative accident risk (radiological plus nonradiological fatalities) ranged from 0.00087 to 0.0018. The lower number of fatalities was estimated when the barge shipments were made directly to the Savannah River Site. The larger number of fatalities was estimated when the barge shipments were made from Brookhaven National Laboratory to Shoreham, New York, to Hampton Roads, Virginia, to the Savannah River Site.

The consequences of the maximum reasonably foreseeable accident for barge shipments were less than the consequences of the maximum reasonably foreseeable accident for truck shipments, as discussed in Section I-5. This was because the barge routes are further from populations than truck routes.

I-8 TRANSPORTATION IMPACTS OF FOREIGN PROCESSING OF SPENT NUCLEAR FUEL CURRENTLY LOCATED AT THE HANFORD SITE

This section summarizes the transportation impacts of processing the Hanford Site N-Reactor SNF at a foreign processing facility. The detailed assessment of this transportation option, including a description of the foreign processing option and the methods and assumptions used in the analysis, is contained in Volume 1, Appendix A, Attachment B of this EIS.

I-8.1 Radiological Dose to Workers

This subsection describes expected radiological consequences to workers during transportation of N-Reactor SNF currently stored at the Hanford Site. The transportation analysis included shipment from the Hanford Site to representative West and East Coast points of entry (Portland, Oregon; Seattle, Washington; and Norfolk, Virginia) followed by overseas transport to a representative commercial processing facility in the United Kingdom. Overland shipment by barge, truck, or rail was considered as appropriate for each point of entry.

I-8.1.1 Worker Dose from Shipment Preparation Activities at the Hanford Site

Packaging of the K Basin fuel for overseas shipment was estimated to result in worker doses of approximately 140 person-rem (5.5   10-2 latent cancer fatalities) over a period of approximately 2 years. However, if stabilization of the fuel before transport were necessary, an additional 180 person-rem might be accumulated by onsite workers over a 4-year period, resulting in 7.0 10-2 latent cancer fatalities. Consequences of fuel-handling accidents of the K basins are addressed in Volume 1, Appendix A.

I.8.1.2 Worker Doses from Transportation

Collective worker impacts from incident-free transportation were estimated to range from 1.3 X 10^-3 latent cancer fatalities for barge transportation between the Hanford Site and the point of entry at Portland, Oregon, to 4.3 X 10^-2 latent cancer fatalities for the option of transport by truck between the Hanford Site and the point of entry at Norfolk, Virginia. These impacts account for transport of SNF leaving the Hanford Site as well as the return transport of high-level waste, plutonium oxide, and uranium oxide.

Radiological consequences to workers from activities at the point of entry for transport of SNF to the United Kingdom were evaluated based on commercial experience during the last 9 months of 1994.

The consequences for loading and unloading 408 casks during shipment from the United States to the United Kingdom were estimated to be approximately 1.2 person-rem to all workers over the expected 5-year campaign. An additional two fuel-handling activities per cask at the Hanford Site and at the United Kingdom process facility would approximately double that estimate, resulting in a collective dose of 2.4 person-rem and a potential for 9.8 X 10^-4 latent cancer fatalities for all shipments. The maximum dose to an individual worker, assuming that worker was involved in handling all 408 casks at one point in the shipping sequence, would be approximately 0.4 rem over 5 years.

The consequences to a nearby worker were evaluated for accidents at, or on the approach to, the representative points of entry considered in the overland transportation analysis. In addition, the point of entry at Newark, New Jersey, was included in this part of the analysis because of its large surrounding population (it is adjacent to New York City) whereas the other points of entry are located in smaller population centers. The consequences of the maximum reasonably foreseeable accident (frequency >1 10-7 per year) to a worker at a distance of 100 meters (328 feet) ranged from 1.7 rem (6.8 10-4 latent cancer fatalities) at Seattle/Tacoma, Washington, to 2.1 rem (8.4 10-4 latent cancer fatalities) at Portland, Oregon, or Norfolk, Virginia. The corresponding total risks from accidents of all severity categories for 17 SNF shipments were 8.0 x 10^-9 latent cancer fatalities at Seattle/Tacoma to 1.0 10-8 latent cancer fatalities at Norfolk or Portland.

Radiological consequences were estimated for workers as a result of normal transport operations and accidents during overseas shipments of SNF from the Hanford Site to the United Kingdom. The primary impact of routine (incident-free) marine transport of SNF would be potential radiological exposure to crew members of the ships used to carry the casks. While at sea, the crew dose would be limited to those individuals who may enter the ship's hold during transit and receive external radiation in the vicinity of the packaged fuel. The consequences to crew members would depend on the duration of the voyage and the time spent inspecting each cask. Assuming surface dose rates at the regulatory limit, the collective dose to the inspection crew from all SNF shipments could range from 2.4 to 12 person-rem, depending on the routing. Return shipments of high-level waste, uranium, and plutonium would result in lower doses to the crew. All doses to individual crew members would be within administrative control and regulatory limits for radiation workers. Actual commercial experience indicates that worker consequences could be much lower than these bounding estimates.

The consequences of accidents during ocean transit would likely be similar to those of point of entry workers who are near the scene of an accident. Individuals in the immediate vicinity of the impact would probably not survive an accident severe enough to release radioactive materials from a SNF shipping cask. Effects on the ocean environment would not be expected to be discernable because of dispersion during an airborne release.

The frequency of accidents on the open ocean was estimated to be 4.6 X 10^-5 for an average duration voyage of approximately 20 days to transport SNF from foreign research reactors to the United States. The frequency of accidents for overseas shipment of SNF and process materials via ships built for this purpose would likely be within a factor of 2 or 3 of this estimate.

I-8.2 Consequences to Members of the Public

This subsection describes expected consequences to the public from activities required to transport N-Reactor SNF to the United Kingdom.

I-8.2.1 Public Impacts from Shipment Preparation Activities at the Hanford Site

Activities at the Hanford Site before and during preparation for shipment of N-Reactor SNF would result in generally small consequences to the public, as discussed in Volume 1, Appendix A, of this EIS. Removal and packaging of SNF at the K Basins was estimated to result in offsite consequences comparable to those observed during initial segregation of the fuel, or less than 3 X 10^-7 rem (1.5 X 10^-10 probability of latent cancer fatalities) to the maximally exposed offsite individual. The risk from accidents involving handling of N-Reactor fuel at the K Basins is presented in Volume 1, Appendix A, of this EIS.

I-8.2.2 Public Impacts from Transportation Activities

Members of the public exposed to radiation during transportation include persons on the highway, railroad, or waterway with the shipment; persons residing near these transport links; and persons at intermediate stops along the route (such as refueling stops and stops at rail classification yards).

Public impacts from incident-free transportation include radiological impacts from direct radiation as well as nonradiological impacts from vehicle emissions. Radiological impacts from incident-free transportation were estimated to range from 2.1 X 10^-4 latent cancer fatalities for barge transportation between the Hanford Site and the point of entry at Portland, Oregon, to 1.3 X 10^-1 latent cancer fatalities for the option of transport by truck between the Hanford Site and the point of entry at Norfolk, Virginia. Nonradiological impacts from incident-free transportation were estimated to range from 1.2 X 10^-3 latent cancer fatalities for the option of truck transport from the Hanford Site to the point of entry at Seattle/Tacoma, Washington, to 1.6 X 10^-2 latent cancer fatalities for the option of truck transport from the Hanford Site to the point of entry at Norfolk, Virginia.

Public impacts from potential transportation accidents include radiological risks from radioactive materials that could be released to the environment as well as nonradiological risks associated with traffic accidents (i.e., vehicle collisions). Cumulative radiological transportation accident risks range from 1.8 X 10^-6 latent cancer fatalities for the option of rail transport between the Hanford Site and the point of entry at Seattle/Tacoma, Washington, to 4.2 X 10^-5 latent cancer fatalities for either truck or rail transport between the Hanford Site and the point of entry at Norfolk, Virginia. Traffic accident risks range from 8.9 X 10^-3 fatalities for the option of truck transport between the Hanford Site and the point of entry at Seattle/Tacoma, Washington, to 1.3 X 10^-1 fatalities for the option of truck transport between the Hanford Site and the point of entry at Norfolk, Virginia.

The maximum reasonably foreseeable transportation accident involves a return shipment of high-level waste transported by rail from the point of entry at Seattle/Tacoma, Washington, to the Hanford Site. If this accident were to occur in an urban population zone, it could result in an estimated one latent cancer fatality within the affected population. The probability of this accident is about 1.3 X 10^-7 per year.

Normal port activities during transport of N-Reactor SNF are not expected to have any consequences for members of the public other than point of entry workers. The consequences to the public from accidents during point of entry transit were estimated using the same assumptions as for worker consequences. The highest risk to the public from point of entry activities was estimated to result from accidents at the dock. Under stable atmospheric dispersion conditions, the maximum risk to the public was estimated to be 8.4 X 10^-5 latent cancer fatalities. The maximum foreseeable accident resulted in an estimated 380 latent cancer fatalities in the population within 80 kilometers (50 miles) of Newark, New Jersey. The estimated frequency of this accident was 2.2 X 10^-7 for 17 overseas shipments of SNF.

There is not expected to be any dose to members of the public or marine life resulting from incident-free ocean transport of N-Reactor SNF to the United Kingdom. The effects of losing a cask at sea are estimated to be comparable to those evaluated for transporting foreign research reactor SNF to the United States based on similar shipping inventories of long-lived radionuclides per cask. The maximum dose to an individual for a cask lost in coastal waters was expected to be 11 millirem per year if the cask was left in place until all its contents dispersed. The corresponding consequences to marine biota were 0.24 millirad per year for fish, 0.32 millirad per year for crustaceans, and 13 millirad per year for mollusks. The consequences resulting from loss of a cask in the deep ocean would be many orders of magnitude lower than the estimates for coastal waters.

I-9 HISTORICAL SPENT NUCLEAR FUEL TRANSPORTATION ACCIDENTS

Transportation incidents for 1949 through 1970 were surveyed using summary reports prepared by the U.S. Atomic Energy Agency (AEC 1957, Patterson and DeFatta 1962, Patterson and Mehn 1963, AEC 1966, McCluggage 1971). In these summary reports, incidents are classified into six classes based on the extent of radioactive material release (Patterson and DeFatta 1962) and accidents and incidents are not differentiated. For 1949 through 1970, there were 14 incidents involving irradiated fuel elements. No packages approximating a Type B shipping cask were breached as a result of these incidents (McCluggage 1971). Two representative incidents are summarized below.

On November 15, 1960, a tractor-trailer carrying 7 steel-jacketed lead casks containing 25 irradiated fuel elements was involved in an accident with a station wagon. The station wagon was completely demolished and the driver killed. The tractor was badly damaged and the driver suffered a broken hand and abrasions. The irradiated fuel elements were undisturbed. This incident was classified as a Class I radiation release, which means that no radioactive material was released and there was no loss of integrity to the package.

In another case (June 2-6, 1960), leakage of contaminated cooling water from a rail shipment consisting of irradiated fuel elements and some ruptured elements in aluminum cans resulted in contamination of three railroad yards. This incident was classified as a Class IV radiation release, which means that radioactive material was released to the ground or trafficway with no runoff or aerial dispersion. There were no injuries associated with this incident.

Spent nuclear fuel transportation accidents for 1971 through 1993 were surveyed based on data in the Radioactive Materials Incident Report database. This database contains information on radioactive materials transportation incidents and accidents from the U.S. Department of Transportation, U.S. Nuclear Regulatory Commission, U.S. Department of Energy, state radiation control offices, and media coverage of radioactive materials transportation incidents and accidents (Cashwell and McClure 1992). The Radioactive Materials Incident Report database contains information on transportation accidents, handling accidents, and reported incidents; this discussion is limited to transportation accidents involving SNF.

Between 1971 and 1993, there were seven transportation accidents involving SNF. Three of these accidents involved rail shipments, and four of these accidents involved truck shipments. These accidents were summarized in Cashwell and McClure (1992). Only one of these accidents resulted in more than minor damage to the SNF cask. On December 8, 1971, a truck transporting a SNF element in a Type B shipping cask on U.S. Highway 25 in Tennessee swerved to avoid a head-on collision with another vehicle and was forced off the road. The driver of the truck was killed by the impact and the SNF cask was thrown into a ditch. The DOE Radiological Assistance Team from Oak Ridge, Tennessee, arrived and surveys indicated that the structural integrity of the cask was intact and there was no release of contents.

I-10 CUMULATIVE IMPACTS OF TRANSPORTATION

I-10.1 Radiological Impacts

The cumulative impacts of the transportation of SNF consist of impacts from (a) historical shipments of SNF to the Hanford Site, Savannah River Site, Idaho National Engineering Laboratory, Oak Ridge Reservation, and the Nevada Test Site; (b) the alternatives evaluated in this EIS; (c) other reasonably foreseeable actions that include transportation of radioactive material; and (d) general radioactive materials transportation that is not related to a particular action. The discussion of cumulative transportation impacts concentrates on the cumulative impacts of offsite transportation, because offsite transportation yields potential doses to a greater portion of the general population than does onsite transportation. The collective dose to the general population and workers is the measure used to quantify cumulative transportation impacts. This measure of impact was chosen because it can be directly related to latent cancer fatalities using a cancer risk coefficient and because of the difficulty in identifying a maximally exposed individual for shipments throughout the United States spanning the period 1943 through 2035 (93 years).

Collective doses from historical shipments of SNF to the Hanford Site, Savannah River Site, Oak Ridge Reservation, and the Nevada Test Site were summarized in Jones and Maheras (1994a, 1994b, 1994c, 1994d). Data for these shipments were available for 1971 through 1993 and were linearly extrapolated back to the start of operations at each site because data before 1971 were not available. For the Hanford Site and Oak Ridge Reservation, the start of operations was 1943; for the Savannah River Site, the start of operations was 1953; and for the Nevada Test Site, the start of operations was 1951. The results of these analyses are summarized in Table I-58.

The historical shipments of SNF to the Idaho National Engineering Laboratory consisted of shipments of naval SNF and test specimens from 1957 through 1995 (see Attachment A to Appendix D of Volume 1 of this EIS). Extrapolation of naval shipments was not necessary because a detailed records search accounted for all shipments. Historical SNF also consisted of shipments of other DOE SNF to the Idaho National Engineering Laboratory besides naval shipments, such as research reactor SNF and special-case commercial SNF (Maheras 1994). Data for these shipments were available for 1973 through 1993 and were linearly extrapolated back to 1953, the start of operations at the Idaho Chemical Processing Plant, because data for 1953 through 1972 were not available. The results of these analyses are also summarized in Table I-58.

There are considerable uncertainties in these historical estimates of collective dose. For example, the population densities and transportation routes used in the dose assessments were based on census data for 1990 and the United States highway and rail system as it existed in 1993.

Table I-58. Cumulative transportation-related radiological collective doses and latent cancer fatalities (1943 to 2035).

Category	Collective occupational dose (person-rem)	Collective general population dose (person-rem)
Historical spent nuclear fuel		
Hanford Site (1943 to 1993)	52	27
Savannah River Site (1953 to 1993)	50	29
Idaho National Engineering Laboratory (1953 to 1993)		
DOE spent nuclear fuel	56	30
Naval spent nuclear fuel	62	1.6
Oak Ridge Reservation (1943 to 1993)	35	18
Nevada Test Site(a) (1951 to 1993)	1.4	0.70
Spent nuclear fuel shipments for Alternatives 1-5		
Naval(b)	1.5 to 15	0.34 to 12
DOE truck (100%)(c) (1995 to 2035)	0.0 to 1,000	0.0 to 2,300
DOE train (100%)(c) (1995 to 2035)	0.0 to 130	0.0 to 170
Reasonably foreseeable actions		
Geologic repository(c,d)		
Truck (100%)	8,600	48,000
Train (100%)	750	740
Waste Isolation Pilot Plante		
Test phase (100% truck)	110	48
Disposal phase		
Truck (100%)	1,800	1,500
Train (maximum)(f)	68	940
Submarine reactor compartment disposalg	--	0.053
Return of cesium-137 isotope capsulesh	0.42	5.7
Uranium billets(i)	0.50	0.014
General transportation		
1943 to 1982	220,000	170,000
1983 to 2035	89,000	98,000
Summary		
Historical	200	110
Spent nuclear fuel shipments for Alternatives 1-5		
Truck	1.5 to 1,000	0.34 to 2,400
Train	1.5 to 150	0.34 to 190
Reasonably foreseeable actions		
Truck	11,000	50,000

Train	820	1700
General transportation (1943 to 2035)	310,000	270,000
Total collective dose	320,000	320,000
Total latent cancer fatalities	130	160

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a. Shipments from Turkey Point Power Plant in Florida to the Engine Maintenance, Assembly, and Disassembly Facility at the Nevada Test Site.

b. Naval SNF and test specimen shipments based on a combination of truck and rail transport.

c. Shipments based on 100 percent transport by truck or 100 percent transport by rail.

d. Reference: DOE (1986)

e. Reference: DOE (1990)

f. The maximum rail case is based on rail transport where rail access is available and truck transport where rail access is not available.

g. Reference: USN (1984)

h. Reference: DOE (1994).

i. Reference: DOE (1992).

Using census data for 1990 overestimates historical collective doses because the United States population has continuously increased over the time covered in these assessments. Basing collective dose estimates on the United States highway and rail system as it existed in 1993 may slightly underestimate doses for shipments that occurred in the 1940s, 1950s, and 1960s, because a larger portion of the transport routes would have been on non-interstate highways where the population may have been slightly closer to the road. Data were not available that correlated transportation routes and population densities for the 1940s, 1950s, 1960s, and 1970s; therefore, it was necessary to use more recent data to make dose estimates. By the 1970s, the structure of the interstate highway system was largely fixed and most shipments would have been made on interstates.

Shipment data were linearly extrapolated for years when data were unavailable, which also results in uncertainty. However, this technique was validated by linearly extrapolating the data in SAIC (1991) for 1973 through 1989 to estimate the number of shipments that took place during the time period 1964 through 1972 (also contained in SAIC 1991). The 1973 through 1989 time period corresponded to the time period when data were available for the Idaho Chemical Processing Plant. The data in SAIC (1991) could not be used directly because only shipment counts are presented for 1964 through 1982 and no origins or destinations were listed for years before 1983. Based on the data in SAIC (1991), linearly extrapolating the data for 1973 through 1989 overestimates the shipments for 1964 through 1972 by 20 percent when compared to the actual shipment counts for 1964 through 1972.

Collective doses for SNF shipments associated with Alternatives 1 through 5 were summarized previously in this appendix and in Appendix D of Volume 1 of this EIS (for naval spent nuclear fuel). For truck shipments, the collective dose to workers ranged from 1.5 person-rem (the No Action alternative) to 1,000 person-rem (Centralization at Savannah River), or 0.00060 to 0.40 latent cancer fatalities. Collective dose to the general population ranged from 0.34 person-rem (the No Action alternative) to 2,400 person-rem (Centralization at Savannah River), or 0.00017 to 1.2 latent cancer fatalities. These doses and latent cancer fatalities include shipments of naval SNF and test specimens.

For train shipments, the collective dose to workers ranged from 1.5 person-rem (the No Action Alternative) to 150 person-rem (Centralization at Nevada Test Site), or 0.00060 to 0.060 latent cancer fatalities. Collective dose to the general population ranged from 0.34 person-rem (the No Action Alternative) to 190 person-rem (Centralization at Savannah River), or 0.00017 to 0.095 latent cancer fatalities. These doses and latent cancer fatalities include shipments of naval SNF and test specimens.

Transportation impacts may also result from reasonably foreseeable projects. Two major proposed projects that involve extensive transportation of radioactive material are: (a) shipments of SNF and defense high-level waste to a geologic repository, and (b) shipments of transuranic waste to the Waste Isolation Pilot Plant, located in Carlsbad, New Mexico. DOE is presently determining the suitability of Yucca Mountain, Nevada, as a site for a geologic repository for commercial SNF and defense high-level waste; therefore, the geologic repository was assumed to be located in Yucca Mountain, Nevada, for the transportation cumulative impacts analysis.

Based on the transportation dose assessments presented in DOE (1986), the worker collective dose for truck shipments to a repository was 8,600 person-rem or 3.4 latent cancer fatalities. The collective dose to the general population from truck shipments to a repository was 48,000 person-rem or 24 latent cancer fatalities. The worker collective dose for train shipments to a repository was 750 person-rem or 0.30 latent cancer fatalities. The collective dose to the general population from train shipments to a repository was 740 person-rem or 0.37 latent cancer fatalities.

Based on the transportation dose assessments presented in DOE (1990), the worker collective dose from truck shipments to the Waste Isolation Pilot Plant was 1,900 person-rem or 0.76 latent cancer fatalities. The collective dose to the general population from truck shipments to the Waste Isolation Pilot Plant was 1,500 person-rem or 0.75 latent cancer fatalities. The worker collective dose from train shipments to the Waste Isolation Pilot Plant was 180 person-rem or 0.072 latent cancer fatalities. The collective dose to the general population from train shipments to the Waste Isolation Pilot Plant was 990 person-rem or 0.50 latent cancer fatalities. These collective doses include the 5-year Test Phase and the 20-year Disposal Phase.

There are three other reasonably foreseeable projects that involve limited transportation of radioactive material: (a) 100 shipments of submarine reactor compartments from the Puget Sound Naval Shipyard to the Hanford Site for burial, (b) return of cesium-137 isotope capsules to the Hanford Site, and (c) transport of uranium billets from the Hanford Site to the United Kingdom. The transport of submarine reactor compartments is an ongoing activity that is not yet completed; therefore, it was categorized as a reasonably foreseeable action. The doses for these actions are presented in Table I-61.

There are also general transportation activities that take place that are unrelated to the alternatives evaluated in this EIS or to reasonably foreseeable actions. Examples of these activities are shipments of radiopharmaceuticals to nuclear medicine laboratories and shipments of commercial low-level radioactive waste to commercial disposal facilities. The U.S. Nuclear Regulatory Commission evaluated these types of shipments based on a survey of radioactive materials transportation published in 1975 (NRC 1977). Categories of radioactive material evaluated in NRC (1977) included: (a) limited quantity shipments, (b) medical, (c) industrial, (d) fuel cycle, and (e) waste.

The U.S. Nuclear Regulatory Commission estimated that the annual collective worker dose for these shipments was 5,600 person-rem or 2.2 latent cancer fatalities. The annual collective general population dose for these shipments was estimated to be 4,200 person-rem or 2.1 latent cancer fatalities. Because comprehensive transportation doses were not available, these collective dose estimates were used to estimate transportation collective doses for 1943 through 1982 (40 years). These dose estimates included SNF and radioactive waste shipments and truck and rail shipments.

Based on the transportation dose assessments in NRC (1977), the cumulative transportation collective doses for 1943 through 1982 were 220,000 person-rem for workers and 170,000 person-rem for the general population. These collective doses correspond to 88 latent cancer fatalities for workers and 85 latent cancer fatalities for the general population.

In 1983, another survey of radioactive materials transportation in the United States was conducted

(Javitz et al. 1985). This survey included U.S. Nuclear Regulatory Commission and Agreement State licensees and the U.S. Department of Energy. Both SNF and radioactive waste shipments were included in the survey. Weiner et al. (1991a, b) used the survey by Javitz et al. (1985) to estimate collective doses from general transportation. The transportation dose assessments in Weiner et al. (1991a, b) were used to estimate transportation doses for 1983 through 2035 (53 years). The interval 1995 through 2035 corresponds to the interval of time associated with the spent nuclear fuel management activities evaluated in this EIS.

Weiner et al. (1991a) evaluated eight categories of radioactive material shipments by truck: (a) industrial, (b) radiography, (c) medical, (d) fuel cycle, (e) research and development, (f) unknown, (g) waste, and (h) other. Based on a median external exposure rate, an annual collective worker dose of 1,400 person-rem and an annual collective general population dose of 1,400 person-rem were estimated. These collective doses correspond to 0.56 and 0.70 latent cancer fatalities per year for workers and the general population, respectively. Over the 53-year time period from 1983 through 2035, the collective worker and general population doses would be 74,000 person-rem or 30 and 37 latent cancer fatalities for workers and the general population, respectively.

Weiner et al. (1991b) also evaluated six categories of radioactive material shipments by plane: (a) industrial, (b) radiography, (c) medical, (d) research and development, (e) unknown, and (f) waste. Based on a median external exposure rate, an annual collective worker dose of 290 person-rem and an annual collective general population dose of 450 person-rem were estimated. These collective doses correspond to 0.12 and 0.23 latent cancer fatalities per year for workers and the general population, respectively. Over the 53-year time period from 1983 through 2035, the collective worker dose would be 15,000 person-rem and the general population collective dose would be 24,000 person-rem or 6.0 and 12 latent cancer fatalities for workers and the general population, respectively.

Like the historical transportation dose assessments, the estimates of collective doses because of general transportation also exhibit considerable uncertainty. For example, data for 1975 were applied to general transportation activities from 1943 through 1982. This approach probably overestimates doses because the amount of radioactive material that was transported in the 1950s and 1960s was less than the amount transported in the 1970s. For example, in 1968, the shipping rate for radioactive material packages was estimated to be 300,000 packages per year (Patterson 1968); in 1975 this rate was estimated to be 2,000,000 packages per year (NRC 1977). However, because comprehensive data that would enable a more realistic transportation dose assessment are not available, the dose estimates developed by the U.S. Nuclear Regulatory Commission were used.

The total worker and general population collective doses are summarized in Table I-58. Total collective worker doses from all types of shipments (historical, the alternatives, reasonably foreseeable actions, and general transportation) were estimated to be 320,000 person-rem (130 latent cancer fatalities), for the period of time 1943 through 2035 (93 years). Total general population collective doses were also estimated to be 320,000 person-rem (160 latent cancer fatalities). The majority of the collective dose for workers and the general population was because of general transportation of radioactive material. The total number of latent cancer fatalities over the time period 1943 through 2035 was estimated to be 290. Over this same period of time (93 years), approximately 28,000,000 people would die from cancer, based on 300,000 latent cancer fatalities per year (NRC 1977). It should be noted that the estimated number of transportation-related latent cancer fatalities would be indistinguishable from other latent cancer fatalities, and the transportation-related latent cancer fatalities are 0.0010 percent of the total number of latent cancer fatalities.

I-10.2 Vehicular Accident Impacts

Fatalities involving the transport of radioactive materials were surveyed for 1971 through 1993 using the Radioactive Material Incident Report database. For 1971 through 1993, 21 vehicular accidents involving 36 fatalities occurred. These fatalities resulted from vehicular accidents and were not associated with the radioactive nature of the cargo. No radiological fatalities because of transportation accidents have ever occurred in the United States. During the same period of time, over 1,000,000 persons were killed in vehicular accidents in the United States.

For Alternatives 1 through 5, 0.047 to 1.4 vehicular accident fatalities are estimated to occur. During the 40-year time period from 1995 through 2035, approximately 1,600,000 people would be killed in vehicular accidents in the United States.

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APPENDIX J Spent Nuclear Fuel Management

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Spent Nuclear Fuel Management

This appendix describes a range of technologies potentially available for management of spent nuclear fuel (SNF) and the status of each technology. The identified technologies support the SNF programmatic objective to define a management path and proceed toward ultimate disposition of all U.S. Department of Energy (DOE) SNF. Included are technologies for fuel preparation, storage (stabilization) or, where appropriate, direct interim storage. The stabilization and direct storage technologies may also be applicable to ultimate disposition in some instances. The stabilization technologies selected for discussion range from the minimal to the extensive stabilization processing technologies that could be applied to prepare the SNF for extended interim storage or ultimate disposition. In addition, programmatic and institutional factors, which are considerations in the selection of technology options for application, are discussed. Also presented is a brief description of the types of DOE SNF, particularly as their characteristics apply to the technology options.

J-1 BACKGROUND

During the last 40 years, DOE and its predecessor agencies have generated, transported, received, stored, and reprocessed SNF at facilities in the nationwide DOE complex. This SNF was generated from various sources, including DOE production reactors; the Naval Nuclear Propulsion Program reactors; DOE, university, and other research and test reactors; special-case commercial power reactors; and foreign research reactors. Production reactors were constructed and operated at the Hanford and Savannah River Sites to provide special nuclear material and other radioactive isotopes for the DOE's defense programs. These production reactors are no longer operated. Naval Nuclear Propulsion Program reactors and some test and research reactors are still operating. DOE has reprocessed SNF at the Idaho National Engineering Laboratory, Hanford Site, and Savannah River Site to recover fissile materials (uranium-235 and plutonium-239) and other valuable radionuclides.

More than 100,000 metric tons of heavy metal (MTHM) of SNF was produced by DOE and its predecessor agencies since 1943. In the past, most of the SNF was chemically processed to recover the fissile materials, largely uranium-235 and plutonium-239, either for the national defense programs or reactor research and development.

With the end of the Cold War, DOE and the U.S. Department of Defense reevaluated the scale of their weapons production, nuclear propulsion, and research missions. Because of the lack of need for additional fissile materials, DOE decided in 1992 to phase out reprocessing for the recovery of fissile materials. Approximately 2,700 MTHM of SNF remains that has not been processed. Additionally, approximately 100 MTHM of DOE SNF is expected to be generated in the next 40 years. This DOE SNF, which is in a wide range of enrichments and physical conditions, is stored at various locations in the United States and overseas. This material requires management until a decision regarding its ultimate disposition is reached.

Most of the existing fuel is currently stored in 10- to 40-year-old water pools (designed for temporary storage of SNF until it could be reprocessed) at several locations at the Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site. Smaller quantities are stored at approximately 60 locations nationwide, including 55 non-DOE United States research reactor facilities. The vulnerabilities associated with the storage of SNF are identified in a recent DOE report to the Secretary of Energy entitled, Spent Fuel Working Group Report on Inventory and Storage of the Department's Spent Nuclear Fuel and Other Reactor Irradiated Nuclear Materials and Their Environment, Safety, and Health Vulnerabilities (DOE 1993). A DOE plan of action (Phases I, II, and III) to address these vulnerabilities has been issued (DOE 1994a, b, c).

J-2 SPENT NUCLEAR FUEL

Individual fuel elements and assemblies in nuclear reactors are constructed in many configurations, but they generally consist of the fuel matrix, cladding, and structural hardware. The fuel assemblies and structural hardware constitute the reactor core. Section 1.1.1 of Volume 1 of this EIS presents a summary description of SNF.

The fuel matrix contains the fissile material (typically uranium as a metal, metal alloy, or an oxide). For water-cooled reactors, the matrix form is typically plates or cylindrical pellets. Typically, for gas-cooled reactors, the matrix is particles, which are an oxide or carbide composite of the fuel material encapsulated by a ceramic coating.

Cladding materials surrounding the fuel matrix serve two principal functions: (a) protection of the fuel matrix from corrosion by the fluid that removes heat from the reactor core, and (b) containment of radioactive fission products generated within the fuel during reactor operation. The degree and rate of cladding corrosion varies with reactor design.

The structural hardware serves both to support the fuel assemblies and to maintain a fixed geometry for the fissile materials in the reactor core. For example, structural materials fix the location of the fuel elements relative to one another in a fuel assembly and also fix the location of the fuel assemblies relative to one another in the reactor core. Structural hardware also provides mechanical support for the assemblies and the core, as well as providing defined paths for cooling the core. These functions are essential to control the nuclear reactions in the reactor core and ensure that adequate cooling is provided to all heat-generating regions of the reactor core.

The characteristics of the fuel elements in a reactor are tailored to the purpose of the reactor system. Two examples, important to SNF management, are discussed below. One example is for fuel with high-integrity cladding and the other is for fuel with lesser cladding integrity. Integrity refers to the corrosion resistance of the fuel to the reactor coolant and/or to its corrosion resistance in the environment in which it is stored.

> High-Integrity Fuels Used in Naval Reactors and Nuclear Power Plants. Naval fuels use highly enriched uranium, while nuclear power plant fuels generally use low-enriched uranium. These types of reactors use water for cooling the fuel assemblies. The reactors are

operated at high coolant temperatures and pressures. The design objectives associated with commercial fuel and these reactor types are to maximize power output and minimize time spent refueling. For naval reactors, other design objectives are also critical: ability to withstand battleshock, ability to preclude release of any fission products because operating personnel must live and work in close proximity to the reactor, and ability to change reactor power levels quickly so the ship can alter speed when needed. As a result, the cladding materials are selected to be very corrosion resistant at high temperatures (a zirconium alloy is used). Long-term fuel element integrity is emphasized. From the standpoint of SNF management, such fuel element designs are well-suited for direct storage of the SNF (either wet or dry) without additional stabilization. Aggressive (concentrated) chemical and/or mechanical means are required to remove cladding if fuel processing is considered as an option for stabilization.

Savannah River Production Reactor Fuels (and targets). The Savannah River Site production reactors also used water for cooling fuel assemblies. However, the reactors were operated at relatively low temperatures and essentially at atmospheric pressure. The design of these production reactor cores was optimized for production of special nuclear materials and other valuable radioactive isotopes. Fuel irradiation times were generally on the order of a few months. Fuel element cooling times prior to reprocessing were relatively short because the fuel elements were designed for special nuclear materials production and recovery. A high degree of corrosion resistance for the cladding was not part of the design. Aluminum cladding was selected so that the fuel elements could be dissolved for processing by less highly concentrated chemical solutions than for fuel with higher integrity cladding. Therefore, this fuel type is not as suitable for long-term storage (either wet or dry) as are the higher integrity fuels.

The DOE SNF represents a broad spectrum of fuel element designs, both for the fuel matrix material and the cladding. To provide perspective, the characteristics of the principal types of DOE SNF are briefly discussed below. Inventories for the various types (current and projected), in units of MTHM, are summarized in Table J-1, along with a qualitative statement regarding fuel element enrichment and cladding integrity.

J-2.1 Category 1-Naval Fuel

This SNF type includes the fuel from the Naval Nuclear Propulsion Program, including fuel from submarines, surface vessels, and prototype reactors. Naval fuel is highly enriched and is clad with a zirconium alloy. This fuel design is structurally strong (able to withstand battleshock loads well in excess of 50 times the force of gravity), the cladding is highly corrosion-resistant (no release of fission products), and the fuel is designed to operate for more than 20 years.

J-2.2 Category 2-Aluminum-Clad Production Reactor Fuel

The principal source of DOE aluminum-clad SNF was target and driver fuel from the Savannah River Site defense production reactors. The driver fuel is highly enriched aluminum-uranium alloy clad with aluminum. Most of the targets are depleted uranium metal (containing less uranium-235 than natural uranium), also clad with aluminum. Corrosion resistance of the cladding is moderate. Aluminum cladding is susceptible to corrosion when stored in water pools with poor water quality. Also, this category is used for SNF from the Advanced Test Reactor at the Idaho National Engineering Laboratory, some domestic and foreign research reactors SNF, and some production reactor fuel at the Hanford Site. With proper water quality, this fuel has been stored for more than 20 years without cladding corrosion problems.

Table J-1. Spent nuclear fuel inventories and corrosion resistance

Some of the fuel and targets have been in storage in water pools (with poor water quality) since 1989. Fuel is showing signs of corrosion, and targets are heavily corroded.

J-2.3 Category 3-Zirconium-Clad Production Reactor Fuel

All fuel in this category is from the Hanford Site N Reactor. It consists of a low-enriched uranium alloy fuel matrix, clad with a zirconium alloy. The fuel irradiation times were such that relatively large concentrations of fissile plutonium were produced.

Some of the N-Reactor's SNF has been in storage for over 20 years and a large number of fuel elements have holes in the cladding (breached), which permits corrosion of the fuel matrix. One result is contamination of the water in the storage pools at the Hanford Site. With respect to fuel with breached cladding, it is known that the irradiated metallic uranium can undergo reactions with water to produce uranium hydrides. The hydrided, irradiated uranium can be pyrophoric (subject to spontaneous burning) if it is permitted to dry out and is exposed to air (ITAT 1994). The potential pyrophoric nature of the fuel is an important consideration as management strategies for this fuel (including stabilization and transportation) are evaluated.

J-2.4 Category 4-High-Temperature Gas-Cooled Graphite Reactor Fuel

Graphite-matrix fuel was primarily used in two gas-cooled, commercial reactors: Fort St. Vrain and Peach Bottom. This type of fuel consists of small pellets of highly enriched uranium-carbide fuel surrounded by layers of pyrolytic carbon and protective layers of other carbide compounds that serve as the primary cladding. The pellets are dispersed in much larger graphite structures that provide neutron moderation and secondary containment. The fuel has high corrosion resistance when stored dry. However, the fuel is not amenable to wet storage.

J-2.5 Category 5-Commercial Reactor Research and Development Fuel

DOE has participated in numerous commercial reactor and SNF safety investigations. These activities have resulted in accumulations by DOE of SNF elements from a number of commercial reactors. Typically, this SNF consists of zirconium-alloy-clad, low-enriched uranium oxide fuels. Many of these elements were examined in DOE analytical facilities; others were used in test reactors to study fuel behavior in simulated accidents. The damaged core from the Three Mile Island-Unit 2 reactor was investigated extensively by DOE, under cooperative research and development agreements, at several DOE sites. This damaged fuel is also included in this category.

J-2.6 Category 6-Test and Experimental Reactor Fuels

This is a category of fuels of broad description. The fuels range from low to high enrichment and encompass metal, metal alloy, and oxide fuel matrices. The fuel can be divided into three categories.

J-2.6.1 Category 6a-Stainless-Steel-Clad Fuels from Experimental Reactors

Uranium enrichments are generally high in fuels from these reactors, but low-enrichment fuels are included as well. Fuel matrices consist of uranium-zirconium hydride, uranium dioxide, plutonium oxide, plutonium alloy, uranium carbide, uranium metal, and uranium alloys. The principal sources of fuel in this category are the Experimental Breeder Reactor-II and Zero Power Physics Reactor at the Idaho National Engineering Laboratory, Hanford Fast Flux Test Facility, and the blanket assemblies from the FERMI reactor.

J-2.6.2 Category 6b-Zirconium-Alloy-Clad Spent Nuclear Fuel from Experimental Reactors

Typically, fuel in this category has a uranium dioxide fuel matrix, but there is uranium-molybdenum alloy fuel also in this inventory. Enrichment can be either high or low. Most of this SNF originated at the Shippingport Power Reactor where the light water breeder reactor concept was tested. Some thorium and uranium-233 fuels are found in this category.

J-2.6.3 Category 6c-Miscellaneous Fuel

Fuel in this miscellaneous category is derived mainly from the Molten Salt Reactor Experiment at the Oak Ridge Reservation. That fuel is now stored in the salt storage tanks beneath the reactor.

J-3 SPENT NUCLEAR FUEL INTERIM MANAGEMENT OPTIONS

In 1992, the Secretary of Energy directed the DOE to develop an integrated long-term SNF management program. The program is assessing DOE's current SNF inventory and SNF storage facilities, integrating DOE's many existing SNF activities into one program, developing an integrated decisionmaking and policy basis for SNF operations, and ensuring that all issues associated with SNF are resolved safely and cost effectively.

Until ultimate disposition is determined, it is not possible to define the SNF characteristics suitable for ultimate disposition. Pending selection of an ultimate disposition, SNF must be maintained in safe storage. Solutions to the storage questions may require changes in management strategies for these fuels, including such options as the construction of new facilities and stabilization of certain fuels.

Technologies for SNF management are required to ensure safe, environmentally sound, and economic management until ultimate disposition is implemented. There are a number of technology options available for accomplishing these objectives. Key design factors to be considered include the fuel design, structural integrity of the fuel, degree of corrosion of the cladding, fuel enrichment, and the chemical stability of the cladding and the fuel matrix. The principal technology option categories for storage are outlined in a general way on a flow chart (Figure J-1).

The options for SNF management include direct storage (high-integrity fuels) or SNF stabilization in preparation for continued storage. Technologies included under SNF stabilization are containerization, processing without separation of fissile materials, and processing in which there is separation of the fissile material. The status of technologies for each of the approaches are discussed in Section J-4. Related institutional factors associated with implementing the various management approaches are discussed in Section J-5.

Figure J-1. Technology options for preparing spent nuclear fuel for interim storage.

J-4 SUMMARY OF TECHNOLOGIES FOR SPENT NUCLEAR FUEL MANAGEMENT

In 1992, DOE had proposed to engage in research and development activities for technology development and demonstration required to ensure that SNF could be appropriately prepared for disposition in a geologic repository. Any such repository is not expected to be available until after the year 2010. Therefore, DOE has changed its focus in this effort to better define the SNF research and development program. The DOE is utilizing a system approach (a logical, structured approach to assure effective actions) to technology development for preparing SNF for safe interim storage and ultimate disposition in a geologic repository.

Figure J-1 summarizes the technology options available for preparing SNF for interim storage. Indicated under each of the four general categories on the figure is a range of representative technology options. This section describes technology options listed on Figure J-1 and discusses the following:

The option (describes what it involves)

Applicable fuel types

Maturity (demonstrated technology, early stages, or developmental)

Status of commercial and foreign applications/development that may be applicable to DOE SNF management

References that contain more detail on the technology.

When evaluating SNF management options, criticality control is an important factor, particularly for SNF with enriched uranium fuel.

Criticality considerations apply for both direct storage and stabilization. The storage system must meet applicable requirements governing nuclear criticality, which specify that the system be designed to ensure that a nuclear criticality is not possible unless at least two independent (concurrent or sequential) changes occur in the systems essential to the control of nuclear criticality.

Also important in selecting management options for SNF are the characteristics of the fuel type and the physical condition of the fuel. For specific types of fuel, characterization may be necessary to determine the extent of stabilization required and/or the most suitable stabilization process to transition the particular SNF into interim storage.

J4

J-4.1 Direct Storage

Direct storage means storing SNF in essentially the same physical form in which it is removed from the reactor (that is, little or limited stabilization of the fuel elements). Fuel that has high-integrity cladding is amenable to direct storage provided criticality issues can be adequately addressed for the planned storage interval (IAEA 1988). Specific examples are naval SNF and SNF removed from most types of commercial nuclear electric generating stations (both in the United States and foreign countries).

If a reactor that has operated at high power has fuel removed soon after shutdown (within weeks), the level of heat generation associated with fission product decay may be sufficient to damage and possibly melt the fuel if the fuel assembly is not cooled adequately. In addition, radiation levels are high from decaying fission products and radionuclides in the irradiated structural materials. Thus, both effective cooling and effective shielding of the stored SNF are essential. Common practice is to place the SNF in a water pool, for at least a period of time, following removal from the reactor. The level of heat generation and radioactive decay associated with SNF decreases with time after removal from the reactor. With the passage of time, it is possible and may be desirable to transfer SNF from a wet to a dry storage mode because, in general, the costs and potential environmental safety and health vulnerabilities associated with dry storage are less than those associated with wet storage (Lopez 1994, Taylor and Shikashio 1993). The status of wet and dry storage technologies is discussed in the following two subsections.

J-4.1.1 Wet Storage

Water pools (or water pits) are part of the design of nearly all nuclear reactor facilities. They are used to provide a storage location for SNF when it is removed from the reactor. The pools usually are designed to store the inventory of fuel removed from a reactor for a number of years. Pool depth is sufficient to provide shielding for personnel working in the region of the water pool. The water pool system normally includes a subsystem for water chemistry control with a purpose of maintaining the conditions of the water in the pool so cladding corrosion is minimized, water in the pool is clean enough that the SNF can be viewed underwater during fuel movement and fuel removal operations, and chloride content is controlled to maintain pool liner integrity. The water pools usually are of concrete construction and lined with stainless steel so as to minimize the potential accumulation of radioactivity on or under the surface of the concrete pool walls.

Wet storage systems generally have more heat removal capability than dry storage systems because heat transfer to liquids is more efficient than to gases, such as air or nitrogen.

Design, construction, and operation of water pools for SNF storage is a mature technology option for DOE and for commercial nuclear power plants (Tak-ts 1994). Wet storage system design modifications usually center around re-racking the fuel in a pool to permit more fuel to be stored in a given pool. Fuel element spacing in rack designs is carefully analyzed to ensure that there is an adequate margin relative to criticality prevention for existing or contemplated SNF to be stored in the racks in the water pool.

J-4.1.2 Dry Storage Systems

In a dry storage system, cooling is provided by heat transfer to the inner wall of the storage system with eventual heat rejection to the air surrounding the storage system. Dry storage systems are mature technologies that are being applied for DOE SNF and for SNF at United States commercial and foreign nuclear electric generating systems (Schneider et al. 1992).

Dry storage system options generally are of three types: (a) stand-alone modular casks, (b) modular vault arrays, and (c) multiple-unit vault storage systems. Hot cells are also employed but are not generally considered cost efficient for storing significant quantities of SNF. Multiple examples of each of these three types have been built and are storing SNF at the present time in DOE, commercial, and foreign applications.

Stand-Alone Modular Casks. A number of large stand-alone casks are available in the DOE system and in commercial applications. The casks are top- or end-loading, made from a variety of materials, and have been developed primarily in North America and Europe (Monthey and Bergsman 1994). Some cask designs are licensed for offsite transport of SNF and others are used principally for onsite fuel movement.

There are also a variety of smaller stand-alone casks that are designed primarily for onsite transportation and storage of specific irradiated fuels and other materials. The safety basis documentation for these casks can be found in accompanying safety analysis reports (for example, Saito 1992).

Modular Vault Arrays. A second type of dry storage system uses a basic concrete housing with an arrangement of openings in the concrete. Canisters containing fuel are placed in the openings. The concrete housing provides supplementary shielding and prohibits unauthorized access to the SNF. Depending on the design, fuel can be stored either vertically or horizontally in canisters.

Multiple-Unit Vault Storage Systems. Multiple-unit vault systems tend to be large facilities that contain cask unloading stations, fuel handling cells, ventilation systems, and office space (Carter 1994). In the main storage area array, fuel assemblies or fuel assemblies in canisters are stored vertically in floor wells topped with shielded plugs. Insertion or removal of a canister containing the fueled component is accomplished using a shielded, floor-supported machine or a wall-mounted, unshielded bridge crane.

J-4.2 Containerization

Some SNF has deteriorated because of past storage conditions, fuel damage during operation or destructive tests, or use of cladding materials that are quite susceptible to deterioration if placed in prolonged wet storage without adequate protection. To provide adequate protection for the public, environment, and facility workers, containerization technologies have been employed to (a) add additional containment to the SNF, (b) provide a passivating environment for the spent fuel (a passivating environment is one where corrosion is minimized), or (c) place the spent fuel into an inert atmosphere to retard or eliminate the fuel-element deterioration process. These technologies are described below.

J-4.2.1 Canning

Canning is the technology whereby the SNF is placed into an engineered metal canister, which then is usually sealed. This technology (commonly called overpacking) is usually done in a water pool. Overpacking is used as a temporary corrective action if the SNF is releasing fission products. Further refinements include blowing the water out of the overpack canister while it is still underwater and then evacuating the canister (vacuum) to evaporate the remaining water. An inert gas, such as helium or nitrogen, can also be added. Another refinement to this technology involves adding a chemical for passivation to the water inside the canister to retard the corrosion of the SNF by the water. This approach has been attempted at the K-West Basin at the Hanford Site; however, its effectiveness is unknown because the fuel has not been inspected since it was canned. Small vents in the lid of the can, which allow release of gases generated by radiolysis or corrosion, have also been used.

Canning can also be carried out in a shielded, dry cell having remote-handling capabilities. The SNF is brought into the remote cell and dried, either by normal drip-drying or employing heating ovens to expedite the drying process. The SNF can be visually inspected in the remote cell and then placed into a metal canister that is welded closed. Inert gas can be added; high quality inspection of the closed canister is also possible.

This technology has been used extensively throughout DOE and foreign countries for research fuels. The commercial industry has not done a significant amount of direct canning because the commercial nuclear fuels have been designed for high integrity and so rarely require an overpack.

J-4.2.2 Passivation

The passivation approach is applicable to SNF that may contain regions that could undergo adverse chemical reactions if exposed to air or moisture during dry storage. Passivation increases the stability of the fuel by reducing its reaction rate with air or other oxidants. Consequently, if the fuel were inadvertently exposed to air during dry storage, the heat generated would be less than the minimum heat dissipation rate, thus minimizing the chances of a fuel fire or rapid adverse chemical reactions. This process potentially could be used to stabilize metallic fuel with damaged cladding, such as Hanford Site N-Reactor fuel.

Passivation could also include preparatory steps such as SNF cleaning, drying, and heating in a controlled environment to remove any bound water or to potentially remove or oxidize uranium hydride. A typical process first involves fuel cleaning. When cleaning is completed, a flow of dry inert gas is introduced around the fuel, which is maintained at the predetermined elevated temperature. A small concentration of oxidant is introduced into the flowing inert gas. Reactive regions of the fuel matrix react with the small amount of oxidant at the elevated temperature to oxidize them and make them nonreactive. When process instrumentation indicates that the reaction rate between the oxidant and the fuel (in the controlled environment) is sufficiently low, the fuel is cooled down and appropriately packaged. The fuel packaging must restrain the fuel from excessive movement to prevent the formation or exposure of new highly reactive fuel regions.

A passivation process has been used on metallic fuel in a laboratory setting by the British, who considered it to be a potentially viable method to transition their SNF from wet to dry storage. Passivation is being investigated for use on N-Reactor fuel at the Hanford Site.

J-4.2.3 Coating

Coating is a technology whereby the SNF is placed into a metal container, dried to remove any water, and then heated to the casting temperature for particular materials such as lead, copper, or an epoxy. The fuel element is covered with the molten material. The intent is to provide monolithic containment around the fuel element to ensure that the SNF will not release any fission products, nor encounter an atmosphere that causes the fuel to degenerate further. To date, this technology has been investigated primarily as an approach for preparing SNF for disposal. Pressing copper around SNF at high pressures has been studied by the Swedish government.

J-4.3 Processing

For over 40 years, DOE has employed aqueous reprocessing. The purpose for reprocessing was to separate plutonium and residual uranium materials in the SNF from the radioactive fission products and structural material, including fuel element cladding.

Some of the SNF that is currently in storage at the Savannah River Site, Hanford Site, and Idaho National Engineering Laboratory shows signs of degraded cladding. Aqueous processing may be a way of preventing safety and environmental problems with fuels that have questionable cladding integrity (DOE 1994a). From the standpoint of SNF stabilization, processing is a technology for which DOE facilities exist and where there are still capable technical and facility operating personnel to staff and support facility operations. By removing part of the SNF inventory from the present wet storage environments, processing affords an additional level of stability for the inventory of stored SNF.

Processing of SNF with separation of fissile materials has a long history of operations. The technology is mature and well understood. The primary process used for fissile materials separation for DOE SNF, commercial fuels, and foreign separations processing has been the PUREX (Plutonium URanium EXtraction) process or variations of this process. Facilities for PUREX-type processing have been built in the United States, a number of European countries, Russia, and Japan. In the United States, all of the recently operating facilities are owned and operated by DOE. With the end of the cold war, DOE and the U.S. Department of Defense reevaluated the need for additional fissile materials and decided in 1992 to phase out processing for recovery of fissile materials. DOE's processing facilities at the Hanford Site and Idaho National Engineering Laboratory are now shut down. One processing facility at the Savannah River Site has recently been restarted to stabilize aqueous solutions of uranium.

While chemical separation is the only technology currently available, there are other technologies that could accomplish fuel processing. The following technologies are intended to provide representative examples of technologies that could be employed for various types of SNF subject to the appropriate National Environmental Policy Act documentation. All technologies are not applicable to all types of fuel.

Several processes have been proposed and studied to stabilize SNF that do not involve separation of uranium and/or plutonium from the other highly radioactive contaminants. These processes involve changing the SNF physical and chemical form to make the volume smaller, material less reactive, or the material more homogeneous. Materials to assist in preventing nuclear criticality (nuclear poison) may also be introduced into the process. Because none of these methods remove fissile material, the possibility of a nuclear criticality exists for DOE SNF with a fuel matrix of highly enriched uranium-235, unless the uranium-235 is diluted with uranium-238 or a nuclear poison is added to assist in preventing nuclear criticality.

J-4.3.1 Oxidation

An oxidation process can be used for two purposes. It can be used to (a) separate the fuel from the cladding, minimize the volume of material to be stored, or prepare the fuel matrix to be more easily dissolved, or (b) convert fuel matrix or graphite fuel elements into a stable oxide form. The decladding options include

AIROX-Holes are drilled into the fuel matrix. Uranium dioxide (UO_2) is oxidized to U_3O_8 by injecting oxygen gas at 400C (750F). There is an increase in fuel matrix volume of about 70 percent. The uranium then is reduced back to UO_2 using hydrogen gas. The process is repeated several times until the cladding breaks apart. This process is in the developmental stages.

RAHYD-Holes are drilled into the fuel matrix. Uranium metal is reduced with hydrogen gas at 225C (435F) to produce uranium trihydride. There is about a 70 percent volume increase. The fuel matrix is then converted back to uranium metal by heating to 780C (1400F). The process is repeated several times until the cladding breaks apart. This process is in the developmental stages.

CARBOX-Holes are drilled into the fuel matrix. Oxygen is injected into uranium carbide fuel at 400 to 700C (750 to 1300F) to form U_3O_8. There is about an 85 percent volume increase. This process is in the developmental stages.

After the fuel is declad, the fuel matrix material can be consolidated and packaged for storage.

Development work was performed on decladding technologies in the late 1950s and early 1960s in connection with dry SNF reprocessing research at Atomics International.

The fuel elements can also be oxidized to convert the cladding and/or the fuel matrix into oxide form. One example is the burning of the graphite and metal fuels. The oxidized fuel and any ash would contain the uranium, plutonium, and most of the fission products, which then would be consolidated and packaged for storage. Technology for burning graphite fuels is well developed and has been used at the Idaho National Engineering Laboratory (WINCO 1992).

J-4.3.2 Chemical Dissolution

The fuel is dissolved chemically by a highly concentrated acid or base solution. If necessary, a nuclear poison can be added to assist in criticality control. Separation of the fissile material from the fission products and cladding material does not occur. The resultant product is converted into an SNF interim storage form, such as a glass, oxide, or ceramic, with improved characteristics relative to criticality control. This process applies to all DOE fuel types except graphite fuel. The dissolution technology is well developed (Long 1978) and has been used throughout the DOE complex and in several foreign countries.

J-4.3.3 Mechanical

Several mechanical processes, such as shredding, chopping, grinding, and disassembly, have been proposed to change the configuration of the fuel. The resultant product can be mixed with other material, such as glass formers or depleted uranium, for safe interim storage. All DOE fuel can be treated by this method. Choppers have been used at several DOE facilities, and shredders have been evaluated at the Idaho National Engineering Laboratory for graphite fuel (WINCO 1992).

J-4.3.4 Aqueous Processing

The primary aqueous extraction processing approach used is called PUREX. Aqueous processing consists of chemically dissolving the fuel in an acid, adjusting the solution pH for stability and uranium extraction, and contacting (mixing) the acid solution with an organic phase, such as kerosene or n-dodecane, usually with tributyl phosphate added (Long 1978, Benedict 1981). The organic compound forms a complex with the uranyl ion that is extracted into the organic phase, thus separating the uranium from other dissolved constituents of the fuel. Depending on the fuel type, the entire fuel element may be dissolved, or the cladding can be breached by chopping the element to enable the acid to leach the fuel matrix. For the chop-leach approach, there remains undissolved cladding hulls. The acid solutions used in the process are tailored to the fuel type. By adjusting the valence of plutonium, it can be separated from the uranium and/or fission products by a series of water-solution-to-organic-phase extraction steps. The PUREX process is applicable to almost all fuel types, if there is a suitable fuel matrix dissolution (headend) process. A process variation called TRUEX, developed at Argonne National Laboratory, can be used to recover the transuranic elements other than uranium or plutonium.

Aqueous processing of SNF utilizing the basic PUREX separation approach is a mature technology and is used world-wide (Leigh 1992). The United States has used PUREX aqueous processing for separating fissile materials from irradiated defense fuels since the 1950s at the Savannah River Site, Hanford Site, and Idaho National Engineering Laboratory. The West Valley Plant in New York, constructed for fissile material extraction from commercial light water reactor fuels, used a PUREX-type process. The United Kingdom, France, Russia, and Japan use large-scale aqueous PUREX processing to recover fissile materials from spent fuels.

J-4.3.5 Electrometallurgical Processing

Electrometallurgical processing employs rapid anhydrous (or water-free) chemical reactions at high temperature for the extraction of metal from mixtures or concentrates and for refining metallic elements and compounds. The process is based on passing an electrical current through fused salts. It involves three steps. First, a basket of chopped fuel is made anodic with respect to the electrorefiner crucible, which promotes rapid dissolution of the fuel into the electrolyte salts. These salts float on a pool of liquid cadmium metal. Second, a metallic cathode is introduced into the salts and much of the uranium is deposited on the metallic cathode (which is removed for uranium recovery). Third, a liquid cadmium cathode is then used to collect the remaining uranium, plutonium, and fission products. Zirconium and noble metals remain in the molten electrorefiner cadmium pool. Most fission products remain in the electrolyte salts. Cadmium in the liquid cadmium cathode can be distilled, leaving the fissile materials and uranium/plutonium for further disposition, as appropriate. The process is being developed at Argonne National Laboratory-West and being demonstrated on a near-commercial pilot-plant scale in the Fuel Cycle Facility at the Idaho National Engineering Laboratory using sodium-bonded metallic fuel. In principle, other metallic fuel can be processed electrometallurgically. This developmental process is unique to DOE with no foreign or commercial counterparts at the present time.

J-4.3.6 Halide Volatility

A dry chloride volatility process is being developed for separation of the nonradioactive bulk cladding material (e.g., zirconium), fissile uranium, and other fissile or nonfissile transuranic products in SNF. This process is in the conceptual stage (Christian 1994). The process involves complete volatilization of a SNF element. Fuel is exposed to chlorine gas at high temperature [greater than 1200-C (2200-F)]. All of the fuel constituents form volatile chlorides. The chloride compounds are separated by scrubbing the gases through a molten zinc chloride bath to remove the fission products and transuranic radionuclides. The fission products and transuranic radionuclides are recovered by evaporating away the zinc chloride. The remaining chloride gases are fractionally condensed to separate and recover nonradioactive constituents, uranium, iodine, and krypton. The process produces a single waste form (e.g., glass) for ultimate disposition. A significant reduction in volume can be achieved. The process can be applied to fuels with almost any of the existing claddings (such as zirconium alloys, aluminum, and stainless steel).

J-4.4 Capabilities of Existing Facilities for Processing Each of the Fuel Types

The current DOE SNF inventory was characterized into six categories as discussed previously in Section J-2 and Table J-1. Table J-2 summarizes the locations for each category of SNF as well as the processing capabilities that might be brought to bear on them. The information in the tables is expanded on below.

Table J-2. Capabilities of existing facilities for processing each type of spent nuclear fuel (SNF).

SNF category	Description	Source	Conditioning and stabilization needs for interim storage	Processing technology status	Existing applicable facilities
1	Metallic fuel with zirconium-alloy cladding	Naval fuel	Excellent condition; minimal stabilization required	Proven on a production scale	Existing Idaho National Engineering Laboratory facilities using second generation dissolution facilities (fluorinel dissolution process cell) and extraction via CPP-601 facility
2	Highly enriched metallic fuel with aluminum clad	Fuel from the Savannah River Site production reactors; Idaho National Engineering Laboratory	Condition varies; stabilization is a near-term issue; fuel in wet storage will degrade further during interim period; long-term dry storage has unresolved questions	Proven on a production scale	Existing Savannah River Site facilities for Savannah River fuel; other research and development SNF can be processed at either the Savannah River Site or Idaho National Engineering

		Advanced Test Reactor driver fuel; some domestic and foreign research reactor fuels			Laboratory
3	Low enrichment, metallic fuel with zircaloy-clad	Hanford Site N-Reactor fuel	Poor condition and degrading; about half of the SNF has breached cladding with fuel leaching; stabilization is a near-term issue	Proven on a production scale	Existing Savannah River Site or Idaho National Engineering Laboratory facilities with new chop-leach head-end; certain foreign facilities exist that have the capability to process N-Reactor SNF
4	Uranium carbide in graphite matrix within a graphite structure UO2 fuel with zirconium	Gas-cooled commercial reactors at Fort St. Vrain and Peachbottom	Excellent condition; minimal stabilization necessary	Proven on a production scale for ROVER SNF; proven on a prototype scale for other graphite fuels	Idaho National Engineering Laboratory or Savannah River Site facilities could be used with a new head-end facility
5	Zircaloy-clad rods typically with low-enrichment UO2 pellets	DOE tests of commercial reactor fuel; damaged Three-Mile Island core debris	Condition excellent with the exception of Three-Mile Island core debris; minimal stabilization necessary	Proven on a production scale	Existing Idaho National Engineering Laboratory or Savannah River Site facilities perhaps with new head-end facility

Table J-2. (cont.)

6a	Various stainless-steel clad fuels with either high or low enrichment	Idaho National Engineering Laboratory and Hanford Site test reactors	Various and sometimes unknown fuel condition. Degradation of some fuels expected because of long storage times	Proven on a production scale for steel-clad high-enriched uranium SNF; prototype demonstrations are needed for other types	Existing Idaho National Engineering Laboratory or Savannah River Site facilities with new or modified head-end
6b	Zircaloy-clad UO2 or U-Mo alloy of high or low enrichment	Shippingport power reactor and various experiment reactors	Various and sometimes unknown fuel condition; degradation of some fuels expected because of long	Proven for some fuel types; others may require further work	Existing Idaho National Engineering Laboratory or Savannah River

			storage times		Site facilities with an upgraded dissolution facility
6c	Liquid uranium-235 in a salt solution, no cladding	Molten salt reactor experiment at Oak Ridge National Laboratory	Unknown; corrosive nature of fuel raises questions regarding present conditions; evidence of corrosion of storage container exists; stabilization will be required	Processing technology yet not identified	None at present

J-5 SPENT NUCLEAR FUEL INSTITUTIONAL CONSIDERATIONS

This section, in a general way, summarizes potential impacts of institutional considerations on SNF management. The institutional factors include availability of an infrastructure of personnel with knowledge and training in SNF management; facility capacity for SNF operations; and availability of equipment, facilities, railheads, and roadways for transport of SNF. These factors are important considerations in evaluating and selecting technology options for SNF management.

J-5.1 Availability of Technical Personnel Trained in Spent Nuclear Fuel Management

The management of SNF requires personnel qualified and experienced in a number of appropriate skill areas and operations. The skill areas include proficiency in the design, fabrication, and use of special tooling; specific training in safety and radiation protection; specific understanding of criticality controls; an understanding of SNF and SNF handling and shipping operations; and emergency preparedness capabilities. Most operations involving SNF must be performed remotely in hot cells.

The disciplines specific to SNF management include mechanical and structural engineering, construction engineering, radiation protection, nuclear safety, industrial safety, chemistry, and nuclear physics.

J-5.2 Availability of Facilities for Spent Nuclear Fuel Management Operations

Important facilities factors to be considered in SNF management include availability and adequacy of existing facilities for storing and stabilizing of SNF and the design requirements for new facilities. Important factors when evaluating existing facilities include fuel type to be handled, fuel integrity, type of storage (for example, wet or dry), stabilization requirements, capacity and condition of dry storage facilities, and any conditioning or processing that could be required for ultimate disposition.

J-5.3 Transport of Spent Nuclear Fuel

Important factors relating to transport of SNF include fuel reactivity or stability, availability of shielded casks, availability of cask-handling cranes with adequate capacity, status of licenses and permits for a particular site, availability of transport equipment and loading and unloading facilities, availability of qualified roadways and/or railheads, and vehicle tracking and communications capabilities.

J-5.4 Safeguards and Security

The management of SNF typically requires rigorous safeguards and security controls to protect the fissile material within the SNF from diversion. In addition, protection of personnel, the public, and environment must be maintained. These requirements result in specific safeguards and security criteria that include access control to areas where SNF is handled, stored, and processed and the maintenance of controlled databases to account for fuels and their inventory of fissile materials.

J-5.5 Current Federal and State Agreements

DOE has entered into agreements with state governments that apply to SNF sites. The DOE agreement with the State of New York provides that the SNF will be removed from the West Valley Site to another DOE site. An agreement among the DOE, Navy, and State of Idaho regarding the Idaho National Engineering Laboratory provides for removal of SNF from underwater storage in the north and middle basins of Building CPP-603 by the end of 1996 and from the south basin of this facility by the end of 2000. There is also an agreement among the DOE, U.S. Environmental Protection Agency, and State of Washington regarding the Hanford Site that requires the removal of SNF and pool sludge from the Building 105-K basins.

J-5.6 Maintaining Flexibility Until Ultimate Disposition is Available

Some stabilization technologies for storage may be undesirable if they could potentially make a later conversion to an acceptable form for ultimate disposition very difficult. For example, SNF stabilized for interim storage could be precluded from ultimate disposition by certain possible acceptance criteria.

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APPENDIX K Environmental Consequences Data

Appendix K

Environmental Consequences Data

This appendix presents data that were used to discuss environmental consequences and to generate the graphics used in comparing environmental consequences among alternatives (in Chapter 3) and among alternatives and sites (in Chapter 5). These data are taken from Volume 1 Appendices A through F and converted as required to different units or time periods. To understand the technical basis and context for each of the reported data elements, refer to the appropriate site appendix:

Hanford Site	Appendix A
Idaho National Engineering Laboratory	Appendix B
Savannah River Site	Appendix C
Naval Nuclear Propulsion Program	Appendix D
Other Generator/Storage Locations	Appendix E
Nevada Test Site and Oak Ridge Reservation	Appendix F

The appendix contains (a) a key to alternatives, (b) a summary of data by alternative, and (c) a summary of data by alternative and site. The key to alternatives defines the site combinations represented by the subalternatives and options and relates these to the columns in Tables K-1 and K-2. The summary of data by alternative in Table K-1 presents the summed (or maximum) impacts across all sites involved in that alternative, subalternative, and option. The summary of data by alternative and site in Table K-2 presents data for each site that is affected by that alternative, subalternative, and option. Those sites not affected by a particular option are not shown.

Ten categories of data, numbered in the first column of the attached tables, were used to develop the discussions and graphs in Chapter 5 and are summarized by discipline below.

1. Land Use-The value presented is an estimate of the amount of additional acreage that would be disturbed if a particular alternative was implemented. Minimum and maximum values were provided for options within each alternative where available. The maximum percent of the total site area that would be dedicated to spent nuclear fuel (SNF) management activities was also calculated. Land use impacts are discussed in Section 5.2.1 of Volume 1. A detailed discussion on land use is provided in Appendices A through F.

2. Employment Related to SNF Management-The values presented are the projected 10-year average changes in site employment related to proposed SNF management activities for the period from 1995 to 2005. Minimum and maximum values were calculated where data were available. Baseline site employment refers to the sitewide employment at June 1995, inclusive of those employed in SNF management activities. The maximum percent of baseline site employment represents the maximum incremental change in sitewide employment that might occur because of the proposed SNF management activities. SNF-related employment is discussed by alternative in Section 5.1, Chapter 5, Volume 1. A detailed analysis of socioeconomic impacts is provided in Appendices A through F.

3. Population Collective Dose-The radiation dose that would be received by the population within 80 kilometers (50 miles) of each site per year from normal operations. It is derived from data in the site appendices and represents the dose for the maximum option within each alternative. Because of the differences in methods used to generate the data, the estimated SNF management doses are

sometimes higher than total site doses. The SNF management doses were developed by modeling releases from existing and proposed facilities, and sitewide doses were determined by a combination of modeling of existing facilities and monitoring data. The monitoring data are more accurate, while the modeling approach overestimates expected dose, making the expected dose higher than would probably be realized. Population collective doses are described by alternative in Section 5.1, Chapter 5, Volume 1.

4. Maximally Exposed Individual (MEI)-The MEI is a hypothetical person located downwind at the site boundary closest to the facilities that might have radiation releases. The MEI doses are calculated by modeling releases from existing and proposed facilities from normal operations. Data on the MEI doses can be found in Appendices A through F and represent the dose for the maximum option within each alternative.

5. Worker Dose-The dose that would be received by workers at facilities, based on expected radiation levels at those facilities for normal operations. Sitewide worker doses are based on historical monitoring of workers. These values are not particularly useful in comparing among sites or alternatives as worker doses are controlled by limiting worker involvement in activities that could result in exposures to radiation. Both individual doses and collective doses to workers are taken from Appendices A through F.

6. Water Use-The values represent an estimate of the change in annual consumption of water (in millions of gallons) that may result from the proposed SNF management activities for a given alternative. Minimum and maximum values are provided where available. The baseline water use is the annual water consumption for a site for all operations. The maximum percent of baseline site water represents the annual maximum incremental change in water use that would occur because of the proposed SNF management activities. Water impacts are discussed in Section 5.2.6, Chapter 5, Volume 1. A detailed discussion of water use and related consequences is provided in Appendices A through F.

7. Electricity Use-The values represent an estimate of the change in annual power consumption (in megawatt-hours per year) that would result from the proposed SNF management activities for a given alternative. Minimum and maximum values are provided where available. The baseline site electricity use is the annual power consumption for a site for all operations. The maximum percent of site electricity use represents the annual maximum incremental change in power consumption that would occur because of the proposed SNF management activities. Electricity use is discussed by alternative in Section 5.1, Chapter 5, Volume 1. A detailed discussion of electricity use is provided in Appendices A through F.

8. Sewage-The values represent an estimate of the change in annual rate of wastewater generation (in millions of gallons) that would result from the proposed SNF management activities for a given alternative. Minimum and maximum values are provided where available. The baseline site sewage value represents the annual volume of wastewater generated from total site operations. The maximum percent of baseline site sewage represents the annual maximum incremental change in wastewater generation that would occur because of the proposed SNF management activities. Wastewater generation is discussed in Section 5.2.9 of Volume 1. A detailed discussion of wastewater generation is provided in Appendices A through F.

9. Waste Volume Estimates (high-level, transuranic, mixed, and low-level waste)-The annual generation rate of these waste types (in cubic meters per year) from the proposed SNF management activities is provided. These values represent 10-year cumulative generation rates divided by ten.

Minimum and maximum values are provided where available. The waste volumes are discussed by alternative in Section 5.1 of Volume 1. A detailed discussion of the waste-generating activities at each site is provided in Appendices A through F.

10. Facility Accidents-For accidents, the individual and collective dose values in the tables represent the consequences for the accident having the highest radiological risk (dose times frequency, not necessarily the highest dose) to the public or to workers. The accidents selected for reporting are not necessarily the same for workers and the general population. In each category, the accident with the highest risk was selected, which may be different for workers and the general population. Doses and risks in Table K-2 are the maximum values from each alternative in Table K-1. Accident analyses reported in this summary are based on SNF management-related activities only and are found in the site appendices. Doses from accidents are described by alternative in Section 5.1 of Volume 1. The Savannah River Site did not quantify the worker dose for the maximum risk accident because the safety analysis reports from which accident information was extracted were prepared before the issuance of DOE Order 5480.23 (DOE 1992). Before 1992, applicable DOE orders did not require the inclusion of worker doses in safety analysis reports. Appendix C to Volume 1 of this EIS provides a co-located worker dose rather than a worker dose for the maximum risk accident.

11. Transportation-For incident-free transportation, the values in Table K-2 represent the total annual average fatalities from shipments of SNF for each alternative. Total fatalities are the sum of radiation-related latent cancer fatalities for transportation workers and the general population, plus nonradiological fatalities from vehicular emissions. These data are an aggregate of the data presented in Appendices A, B, C, D, and I. For transportation accident risks, two sets of data are presented in Table K-2 for each alternative. The estimated risks of cancer fatalities represent the radiological risk from transportation accidents. The estimated risk of traffic fatalities represent the nonradiological risk from traffic accidents. Both quantities are on an annual average basis. These data are an aggregate of the data presented in Appendices D and I.

The data in Table K-1 have been rounded to two significant figures, the greatest number of significant figures that can be justified with this analysis. Zero values indicate no impact for that parameter. In the summary table by alternatives, however, missing site data are treated as zeroes, so the impacts for given alternatives can be understated. Missing data are indicated by blanks. Missing values exist only where impacts are expected to be very small or trivial, so the magnitude of underestimation is probably also small.

Table K-1 shows the magnitude of differences between alternatives is very low. To understand observed differences between alternatives, Chapter 5 of this EIS should be consulted. Differences between sites within an alternative require examination of the site-specific appendices for the reasons noted above.

Key to Alternatives and Sites

No Action: Very limited SNF shipments, limited upgrades to facilities, limited stabilization.

Decentralization: Non-DOE sites (except Navy) transport to DOE sites, some upgrades to facilities, stabilization.

- Option A: No examination of naval SNF
- Option B: Limited examination of naval SNF at Puget Sound Naval Shipyard
- Option C: Full examination of naval SNF at Idaho National Engineering Laboratory; SNF returned to Navy sites for storage

1992/1993 Planning Basis: New SNF transported to Idaho National Engineering Laboratory or Savannah River Site, facility upgrades and expansion, stabilization.

Regionalization: SNF transported to regional sites, facility upgrades and expansion, stabilization.

4A: SNF to Idaho National Engineering Laboratory or Savannah River Site depending on fuel type

4B: SNF to Western or Eastern Regional Site depending on geography

Option	Western Regional Site	Eastern Regional Site	Expended Core Facility location
1E	Hanford Site	Savannah River Site	Savannah River Site
1W	Hanford Site	Savannah River Site	Hanford Site
2W	Idaho National Engineering Laboratory	Savannah River Site	Idaho National Engineering Laboratory
3E	Nevada Test Site	Savannah River Site	Savannah River Site
3W	Nevada Test Site	Savannah River Site	Nevada Test Site
4E	Hanford Site	Oak Ridge Reservation	Oak Ridge Reservation
4W	Hanford Site	Oak Ridge Reservation	Hanford Site
5W	Idaho National Engineering Laboratory	Oak Ridge Reservation	Idaho National Engineering Laboratory
6E	Nevada Test Site	Oak Ridge Reservation	Oak Ridge Reservation
6W	Nevada Test Site	Oak Ridge Reservation	Nevada Test Site

Centralization: SNF transported to central site, facility upgrades and expansion, stabilization.

Option A: Hanford Site is the central site
Option B: Idaho National Engineering Laboratory is the central site
Option C: Savannah River Site is the central site
Option D: Oak Ridge Reservation is the central site
Option E: Nevada Test Site is the central site

Hanford	Hanford Site
INEL	Idaho National Engineering Laboratory
SRS	Savannah River Site
ORR	Oak Ridge Reservation
NTS	Nevada Test Site
Navy	Navy shipyards and prototype locations
Other	Small DOE, other government, and university research reactor sites

Table K-1. Summary of impacts by alternatives and by site.
Table K-1. (continued).
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Table K-1. (continued).
Table K-1. (continued).
Table K-1. (continued).
Table K-2. Summary of impacts by alternative.
Table K-2. (continued).
Table K-2. (continued).
Table K-2. (continued).

K. REFERENCES

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APPENDIX L Environmental Justice

CONTENTS

FIGURES

TABLES

Appendix L

Environmental Justice

L-1 INTRODUCTION

in Minority Populations and Low-Income Populations (FR 1994), was released to Federal agencies. This order directs Federal agencies to incorporate environmental justice as part of their missions. As such, Federal agencies are specifically directed to identify and address as appropriate disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority populations and low-income populations. In addition to describing environmental justice goals, Executive Order 12898 directs the Administrator of the Environmental Protection Agency to convene an interagency Federal Working Group on Environmental Justice (referred to below as the Working Group). The Working Group is directed to provide guidance to Federal agencies on criteria for identifying disproportionately high and adverse human health or environmental effects on minority populations and low-income populations. The Working Group is also directed to coordinate with each Federal agency to develop an environmental justice strategy, if a strategy is required by the proposed activities. At the time of this analysis, the Working Group had not issued final guidance on the approach to be used in analyzing environmental justice, as directed by the Executive Order.

The Working Group has issued draft definitions of terms in the Draft Guidance for Federal Agencies on Terms in Executive Order 12898, dated November 28, 1994. These definitions, with slight modifications, were used in the following analysis. Further, in coordination with the Working Group, DOE is developing internal guidance for the implementation of the Executive Order, which has not yet been adopted. Because both DOE and the Working Group are still in the process of developing guidance, the approach used in this analysis might depart somewhat from whatever guidance is eventually issued.

This section provides an assessment of the areas surrounding the 10 sites under consideration for the management of SNF under all programmatic alternatives considered in this volume. It is divided into two sections: (a) the five sites considered for the management of DOE naval SNF only (under the No Action and Decentralization alternatives, and (b) the five DOE sites being considered for the management of all types of DOE SNF under all alternatives. The five sites considered for the management of naval SNF only are the Norfolk Naval Shipyard, Portsmouth, Virginia; Portsmouth Naval Shipyard, Kittery, Maine; Pearl Harbor Naval Shipyard, Honolulu, Hawaii; Puget Sound Naval Shipyard, Bremerton, Washington; and Kesselring Site, West Milton, New York. The five DOE sites considered for the management of some portion or all DOE SNF are the Savannah River Site, Aiken, South Carolina; Oak Ridge Reservation, Oak Ridge, Tennessee; Idaho National Engineering Laboratory, Idaho Falls, Idaho; Hanford Site, Richland, Washington; and Nevada Test Site, Mercury, Nevada.

This assessment includes potential adverse impacts resulting from both onsite activities and associated transportation of materials. Based on this assessment, it is concluded that none of the alternatives analyzed results in disproportionately high and adverse effects on minority populations or low-income communities surrounding any of the sites under consideration for the management of SNF or associated offsite transportation routes.

L-2 PUBLIC COMMENT RECEIVED ON THE DRAFT ENVIRONMENTAL IMPACT STATEMENT

Public comment received on the Draft EIS is addressed in Volume 3, "Response to Public Comment," of this Final EIS. Overall comment indicated a widespread concern about past and present DOE activities on human health and the environment. A small number of comments were received related to environmental justice; these indicated the need for an expanded analysis in the Final EIS, which was previously committed to in the Draft EIS. The most specific comments were received from the U.S. Environmental Protection Agency's Office of Enforcement and Compliance Assurance and the Shoshone-Bannock Tribes on the Fort Hall Indian Reservation. Environmental justice comments pertaining to Volume 1 of this EIS were in essence:

> Although the Draft EIS includes discussions on socioeconomic impacts, it does not state whether the alternatives would affect minority communities and low-income communities (Sanderson 1994).

> The DOE should pay particular attention to any environmental impacts that may affect the Cattaraugus Reservation of the Seneca Nation of Indians, located downstream on Cattaraugus Creek from the DOE's West Valley Site in New York State. Tribal residents engage in subsistence fishing on the river and should be given a full opportunity to participate in the National Environmental Protection Agency process (Sanderson 1994).

> The DOE must meet the requirements of Executive Order 12898 on environmental justice and fully consider the comments of the Shoshone-Bannock Tribes on the Draft EIS and consider the impacts of its proposed actions on the Tribes, the Fort Hall Indian Reservation, and on other disadvantaged populations living in proximity to the Idaho National Engineering Laboratory. It was stated that the Indian Tribes are not just another "minority population," but are governments that have a special relationship to the Federal Government

and its agencies and have certain authorities to regulate others including the United States Government (Tinno 1994, Wolfley 1994).

Pertinent public comments on the topic of environmental justice have been considered in this assessment, which has been expanded over the discussions in the Draft EIS. Consultations have taken place with the Shoshone-Bannock Tribes on the Fort Hall Indian Reservation and the Seneca Nation of Indians on the Cattaraugus Reservation. As a result of consultations with the Seneca Nation of Indians, DOE and the Navy have received a request by this tribe for notification of impending SNF shipments across the Cattaraugus Reservation. Consultations with the Shoshone-Bannock Tribes on the Fort Hall Indian Reservation are specifically addressed in Section 5.20, Volume 2 of this EIS.

L-3 COMMUNITY CHARACTERISTICS

Demographic information obtained from the U.S. Bureau of Census was used to identify minority populations and low-income communities in the zone of potential impact surrounding each of the sites under consideration. This zone is within a circle that has an 80-kilometer (50-mile) radius. This 80-kilometer (50-mile) radius was selected because it was judged to encompass all of the impacts that may occur. This radius also is based on air impact modeling and socioeconomic impact analysis used throughout this EIS. Transportation impacts are assessed within 800 meters (0.5 miles) of transportation routes for incident-free transportation because impacts beyond this distance are negligible. For transportation accidents, an 80-kilometer (50-mile) radius was used.

L-3.1 Methodology

Demographic maps were prepared using 1990 census data available from the U.S. Bureau of the Census. Figures L-1 through L-10 and Figures L-11 through L-20 illustrate census tract distributions for both minority populations and low-income populations for areas surrounding the five naval SNF-specific and five DOE sites being considered for the management of all or some portion of all DOE SNF respectively. These maps are based on an analysis of 1990 United States Bureau of the Census Tiger Line files, which contain political boundaries and geographical features, and Summary Tape Files 3A (as processed by the U.S. Environmental Protection Agency), which contain demographic information (USBC 1992). Data were resolved to the census tract (see definition in Section 3.2) group level.

An 80-kilometer (50-mile) radius circle appears on each map, defining a zone of potential impact. As discussed above, this zone of potential impact for low-income and minority communities is the same as that used for analysis performed in the EIS. The circle has been indexed to the center location of hypothetical or existing major SNF management facilities at each site or a conservative location to identify the maximum number of minority populations and low-income populations.

L-3.2 Definitions

Definitions used to develop community characteristics are as follows:

Census tract: An area defined for the purpose of monitoring census data that is usually comprised of between 2,500 and 8,000 persons, with 4000 persons being ideal. When first delineated, census tracts are designed to be homogenous with respect to population characteristics, economic status, and living conditions. Census tracts do not cross county boundaries. The spatial size of census tracts varies widely depending on the density of settlement. Census tract boundaries are delineated with the intention of being maintained over a long period of time so that statistical comparisons can be made from census to census.

Minority population: A group of people and/or community experiencing common conditions of exposure or impact that consists of persons of the United States classified by the U. S. Bureau of the Census as Negro/Black/African-American, Hispanic, Asian and Pacific Islander, American Indian, Eskimo, Aleut, and other nonwhite persons, based on self-classification by the people according to the race with which they most closely identify. For the purposes of analysis, minority populations are defined as those census tracts within the zone of impact for which the percent minority population exceeds the average of all census tracts within the zone of impact or where the percent minority population exceeds 50 percent of the spacial area for any given census tract. In the case of migrant or dispersed populations, a minority population consists of a group that is greater than 50 percent minority.

Low-income population: A group of people and/or community experiencing common conditions of exposure or impact in which 25 percent or more of the population is characterized as living in poverty (FR 1993) The U.S. Bureau of Census characterizes persons in poverty as those whose income is less than a "statistical poverty threshold." Table L-1 presents the U.S. Census poverty thresholds (USBC 1992) used in this analysis. This threshold is a weighted average based on family size and the age of the persons in the family. For instance, the 1990 census threshold for a family of four was a 1989 income of $12,674 .

Population Base: For the purpose of this analysis, census tracts were included in the analysis if 50 percent of the tract fell within the 80-kilometer (50-mile) radius.

Table L-1. Poverty thresholds in 1989 by size of family and number of related children under 18 years.

Size of family unit	Weighted average threshold ($)	Related children under 18 years								
		None ($)	One ($)	Two ($)	Three ($)	Four ($)	Five ($)	Six ($)	Seven ($)	Eight or more ($)
One person (unrelated individual)	6,310									
Under 65 years	6,451	6,451								
65 years and over	5,947	5,947								
Two persons	8,076									
Household under 65 years	8,343	8,303	8,547							
Household 65 years and over	7,501	7,495	8,515							
Three persons	9,885	9,699	9,981	9,990						
Four persons	12,674	12,790	12,999	12,575	12,619					
Five persons	14,990	15,424	15,648	15,169	14,796	14,572				
Six persons	16,921	17,740	17,811	17,444	17,092	16,569	16,259			
Seven persons	19,162	20,412	20,540	20,101	19,794	19,224	18,558	17,828		

Eight persons	21,328	22,830	23,031	22,617	22,253	21,738	21,084	20,403	20,230	
Nine or more persons	25,480	27,463	27,596	27,229	26,921	26,415	25,719	25,089	24,933	23,973

L-3.3 Distribution of Minority Populations Near Candidate Sites

The minority population characteristics within the 80-kilometer (50-mile) radius of candidate sites for the SNF and INEL EIS are presented in Tables L-2 and L-3. Table L-2 lists the number of minority individuals residing near the candidate sites for the management of DOE naval SNF. Table L-3 lists the number of minority individuals residing near the candidate sites for the management of all or some portion of DOE SNF.

The racial and ethnic composition of the minority population residing near the candidate naval sites is predominantly African-American, with the exception of Pearl Harbor where the main ethnic population is Asian and Native Hawaiian.

The racial and ethnic composition of the minority population residing near the candidate sites for the management of all or some portion of DOE SNF is predominantly African-American at the Oak Ridge Reservation and Savannah River Site; Hispanic, American Indian, and Asian at the Idaho National Engineering Laboratory; Hispanic and American Indian at the Hanford Site; and Hispanic and African-American at the Nevada Test Site.

Table L-2. Minority individuals residing near the candidate sites for the management of DOE naval spent nuclear fuel only per the 1990 census.

Candidate Site	Number of census tracts considered	Number of individuals residing within 80 km of site	Number of minority individuals within 80 km of site	Percent of individuals that are minority	See figure
Kesselring Site	304	1,148,924	65,590	6	L-1
Norfolk Naval Shipyard	386	1,631,671	534,585	33	L-2
Puget Sound Naval Shipyard	643	2,960,229	379,461	13	L-3
Portsmouth Naval Shipyard	522	2,412,691	121,516	5	L-4
Pearl Harbor Naval Shipyard	200	836,465	571,482	68	L-5

Table L-3. Minority individuals residing near the candidate sites for the management of all or some portion of DOE spent nuclear fuel per the 1990 census.

Candidate Site	Number of census tracts considered	Number of individuals residing within 80 km of site	Number of minority individuals within 80 km of site	Percent of individuals that are minority	See figure
Savannah River Site	147	619,959	233,955	38	L-6
Oak Ridge Reservation	211	867,231	49,742	6	L-7
Idaho National	37	172,366	11,722	7	L-8

Engineering Laboratory					
Hanford Site	79	370,807	75,381	20	L-9
Nevada Test Site	4	11,918	759	6	L-10

The spatial distribution by census tract of the minority population within 80 kilometers (50 miles) of each candidate site is shown in Figures L-1 through L-10. As indicated in the legend of each figure, census tracts have been shaded according to the percentage of minority individuals within the area. It should be noted that Bureau of Census tracts often extend into oceans, bays, and lakes to allow for the inclusion of individuals who reside on boats or offshore houses. This is especially noticeable in locations considered only for the management of DOE naval SNF, with the exception of the inland Kesselring Site. Census tract lines have been removed from Puget Sound proper in Figures L-3 and L-13 to improve clarity.

L-3.4 Distribution of Low-Income Individuals Near the Candidate Sites

The low-income population characteristics within the 80-kilometer (50-mile) radius of candidate sites for the SNF and Idaho National Engineering Laboratory EIS are presented in Tables L-4 and L-5. Table L-4 lists the number of low-income individuals residing near the candidate sites

Table L-4. Low-income individuals residing near the candidate sites for the management of naval spent nuclear fuel only per the 1990 census.

Candidate site	Number of census tracts considered	Number of individuals within 80 km of site	Number of low-income individuals within 80 km of site	Percent of individuals that are low-income	See figure
Kesselring Site	304	1,148,924	101,424	9	L-11
Norfolk Naval Shipyard	386	1,631,671	179,336	11	L-12
Puget Sound Naval Shipyard	643	2,960,229	250,452	8	L-13
Portsmouth Naval Shipyard	522	2,412,691	175,830	7	L-14
Pearl Harbor Naval Shipyard	200	836,465	60,093	7	L-15

Table L-5. Low-income individuals residing near the candidate sites for the management of all or some portion of DOE spent nuclear fuel per the 1990 census.

Candidate site	Number of census tracts considered	Number of individuals within 80 km of site	Number of low-income individuals within 80 km of site	Percent of individuals that are low-income	See figure
Savannah River Site	147	619,959	107,764	17	L-16
Oak Ridge Reservation	211	867,231	134,661	16	L-17
Idaho National Engineering Laboratory	37	172,366	23,416	14	L-18
Hanford Site	79	370,807	65,584		

18	L-19			
Nevada Test Site		4	11,918	1,474
12	L-20			

Figure L-1. Minority population distribution within 80 kilometers (50 miles) of the Kesselring Site. Figure L-2. Minority population distribution within 80 kilometers (50 miles) of the Norfolk Naval Shipyard. Figure L-3. Minority population distribution within 80 kilometers (50 miles) of the Puget Sound Naval Shipyard. Figure L-4. Minority population distribution with 80 kilometers (50 miles) of the Portsmouth Naval Shipyard.

Figure L-5. Minority population distribution within 80 kilometers (50 miles) of the Pearl Harbor Naval Shipyard.

Figure L-6. Minority population distribution within 80 kilometers (50 miles) of the Savannah River Site. Figure L-7. Minority population distribution within 80 kilometers (50 miles) of the Oak Ridge Reservation. Figure L-8. Minority population distribution within 80 kilometers (50 miles) of the Idaho National Engineering Laboratory.

Figure L-9. Minority population distribution within 80 kilometers (50 miles) of the Hanford Site. Figure L-10. Minority population distribution within 80 kilometers (50 miles) of the Nevada Test Site.for the management of naval SNF. Table L-5 lists the number of low-income individuals residing near the candidate sites for the management of all or some portion of DOE SNF.

The spatial distribution by census tract of low-income individuals residing within 80-kilometers (50 miles) of each candidate site are shown in Figures L-11 to L-20. As indicated in the legend of each figure, census tracts have been shaded according to the percentage of low-income population within the area.

L-3.5 Limitations of Demographic Data

As discussed in Section 5.8 of Volume 1 of this EIS, characterization of minority and low-income populations residing within a geographical area is sensitive to the basic definitions and assumptions used in conducting the analysis to identify them. Both the Interagency Working Group and DOE are in the process of preparing final guidelines for use in the evaluation of environmental justice. In the absence of final guidance, the definitions and approaches being used by and within Federal agencies could vary. For example, this EIS and the Draft Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor SNF (Draft FRR SNF EIS) present demographic characterizations obtained from the same U.S. Census Bureau database, but use different definitions and assumptions.

The differences in the definitions and assumptions between this EIS and the Draft FRR SNF EIS are as follows:

1. Although both these EISs use the same 1990 U.S. Census Bureau database, this EIS uses data aggregated at the census tract level (2,500 to 8,000 persons), while the Draft FRR SNF EIS uses data aggregated at the block group level (250 to 550 housing units).

2. In some cases, census blocks or tracts lie partly within the area being analyzed; that is, within the 80-kilometer (50-mile) radius around a potential SNF management site. Because the exact distribution of the populations within such blocks or tracts is not available, the data are insufficient to allow a precise count. To address this situation, this EIS includes a low-income or minority population in its analyses if 50 percent or more of the tract falls within an 80 kilometer (50 mile) radius around the site being considered. In similar situations, the Draft FRR SNF EIS assumes that the general population and the minority population are distributed uniformly throughout a block group, and includes the fraction of the low-income or minority population that corresponds to the fraction of the census block group area that falls within the 80-kilometer (50-mile) radius.

Figure L-11. Low-income population distribution within 80 kilometers (50 miles) of the Kesselring Site. Figure L-12. Low-income population distribution within 80 kilometers (50 miles) of the Norfolk Naval Shipyard.

Figure L-13. Low-income population distribution within 80 kilometers (50 miles) of the Puget Sound Naval Shipyard.

Figure L-14. Low-income population distribution within 80 kilometers (50 miles) of the Portsmouth Naval Shipyard.

Figure L-15. Low-income population distribution within 80 kilometers (50 miles) of the Pearl Harbor Naval Shipyard.

Figure L-16. Low-income population distribution within 80 kilometers (50 miles) of the Savannah River Site.

Figure L-17. Low-income population distribution within 80 kilometers (50 miles) of the Oak Ridge Reservation.

Figure L-18. Low-income population distribution within 80 kilometers (50 miles) of the Idaho National Engineering Laboratory.

Figure L-19. Low-income population distribution within 80 kilometers (50 miles) of the Hanford Site.

Figure L-20. Low-income population distribution within 80 kilometers (50 meters) of the Nevada Test Site.

3. This EIS defines low-income populations as those in a poverty status as determined annually by the U.S. Census Bureau, based on the Consumer Price Index, and aggregated by the thresholds set forth by the U.S. Census Bureau (that is, a group of people and/or a community experiencing common conditions of exposure or impact, in which 25 percent or more of the population is characterized as living in poverty), a method used by the U.S. Environmental Protection Agency. The Draft FRR SNF EIS uses the definition of low-income community, established by the U. S. Department of Housing and Urban Development, as an area for which the median household income is 80 percent or below the median household income for the metropolitan statistical area (urban) or county (rural). Both definitions are permitted under the draft guidance developed by the Interagency Working Group.

These different definitions and assumptions have resulted in differences in the characterization of low-income and minority populations. The two sets of data are summarized in Tables L-6 and L-7, and the most significant differences are discussed below.

The minority populations identified are reasonably consistent between this EIS and the Draft FRR SNF EIS, except for results obtained at the Nevada Test Site (the largest proportional difference) and the Hanford Site (the largest difference in numbers of individuals), as shown in Table L-6. The range in results for both locations is due to the different aggregations of the demographic data used (census tracts vs. blocks), and the differences in the methods used to account for the populations of tracts or groups lying only partly within the area being analyzed, as discussed above. For example, both sites are located in rural or sparsely populated regions so that census tracts surrounding the sites are relatively large in geographical area. In addition, the outskirts of Las Vegas, Nevada, begin approximately 80 kilometers (50 miles) from the Nevada Test Site, making the analysis particularly sensitive to differences in treatment of census tracts or block groups that lie partly within a circle of 80-kilometer (50-mile) radius centered at that site. Most areas within the zone of impact of the Nevada Test Site are restricted access and unpopulated lands.

As a result of the different definitions used for the identification of low-income populations, the results of these analyses are markedly different, as shown in Table L-7. Both sets of data are correct. They reflect the fact that different definitions and assumptions can result in different characterizations of low-income populations.

Table L-6. Comparison of the DOE Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement (SNF & INEL EIS) and the Draft Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel (Draft FRR SNF EIS) minority characterization results.

Candidate	Total individuals residing within with 80 kilometers (50 miles)	Minority individuals residing with 80 kilometers (50 miles)	Percentage of minority individuals residing within 80 kilometers (50 miles)

interim storage site	SNF & INEL EIS	Draft FRR SNF EIS	SNF & INEL EIS	Draft FRR SNF EIS	SNF & INEL EIS	Draft FRR SNF EIS
Hanford Site	370,807	383,934	75,381	95,042	20.3	24.8
Idaho National Engineering Laboratory	172,366	176,311	11,722	15,449	6.8	8.8
Savannah River Site	619,959	566,823	233,955	214,016	37.7	37.8
Nevada Test Site	11,918	12,421	759	2,005	6.4	16.1
Oak Ridge Reservation	867,231	863,758	49,742	53,185	5.7	6.2

Table L-7. Comparison of the DOE Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement (SNF & INEL EIS) and the Draft Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel (Draft FRR SNF EIS) low-income characterization results.

Candidate	Total individuals residing within with 80 kilometers (50 miles)		Minority individuals residing with 80 kilometers (50 miles)		Percentage of minority individuals residing within 80 kilometers (50 miles)	
storage site	SNF & INEL EIS (individuals)	Draft FRR SNF EIS (households)	SNF & INEL EIS (individuals)	Draft FRR SNF EIS (households)	SNF & INEL EIS (individuals)	Draft FRR SNF EIS (households)
Hanford Site	370,807	136,496	65,584	57,667	17.7	42.2
Idaho National Engineering Laboratory	172,366	55,109	23,416	22,452	13.6	40.7
Savannah River Site	619,959	197,937	107,764	82,930	17.4	41.9
Nevada Test Site	11,918	4,194	1,474	2,024	12.4	48.3
Oak Ridge Reservation	867,231	335,589	134,661	147,537	15.5	44.0

L-4 ENVIRONMENTAL JUSTICE ASSESSMENT

This assessment of potential environmental justice impacts addresses activities associated with the programmatic management of DOE SNF discussed in this EIS.

L-4.1 Methodology and Definitions

Analysis of environmental justice concerns was based on a qualitative assessment of the impacts reported in Section 5 of Volume 1 of the EIS regarding the proposed action and its alternatives. This analysis was performed to identify any disproportionately high and adverse human health or environmental impacts on minority populations or low-income populations surrounding each of the 10 candidate sites.

For this assessment, the following definitions were used:

Disproportionately high and adverse human health effects: Adverse health effects are measured in risks and rates that could result in latent cancer fatalities, as well as other fatal or nonfatal adverse impacts to human health. Disproportionately high and adverse human health effects occur when the risk or rate for a minority population or low-income population from exposure to an environmental hazard significantly exceeds the risk or rate to the general population and, where available, to another appropriate comparison group.

Disproportionately high and adverse environmental impacts: An adverse environmental impact is a deleterious environmental impact determined to be unacceptable or above generally accepted norms. A disproportionately high impact refers to an impact (or risk of an impact) in a low-income or minority community that significantly exceeds that on the larger community. In assessing cultural and aesthetic environmental impacts, account shall be taken of impacts that uniquely affect geographically dislocated or dispersed low-income or minority populations.

In this assessment, DOE reviewed the human health effects and environmental impacts associated with the siting of the alternatives analyzed in Volume 1 of this EIS. This review included potential impacts arising under each of the major disciplines evaluated for the alternatives, including land use, socioeconomics, water resources, air resources, ecology, health and safety, facility operations, cultural resources, and transportation, which are the sciences pertinent to the identification of environmental impacts in the EIS. Regarding health effects, both normal facility operations and accident conditions were examined, with accident scenarios evaluated in terms of the risk to the public. Likewise, the examination of transportation included both normal and potential accident conditions for both truck and rail transportation of DOE SNF. Special exposure pathways were evaluated with respect to subsistence consumption of fish, game, or native plants.

L-4.2 Results

Potential radiological impacts because of both facility operations and reasonably foreseeable accident conditions are small for all management alternatives and potential sites considered in this EIS. Likewise, the number of potential fatalities due to both radiological and nonradiological exposures to truck or rail transportation are small. There is also little probability of adverse impacts because of subsistence consumption of fish, game, or native plants.

L-4.2.1 Results of Environmental Justice Assessment Near the Alternative Sites

Considered for the Management of Naval Spent Nuclear Fuel Only

The five sites evaluated for the management of naval SNF only are specifically addressed in Appendix D to Volume 1 of the EIS. Additional environmental justice matters pertaining to the naval sites are included in Appendix D. It should be noted that, with one exception, these five alternative sites are only considered for storage of naval SNF under the No Action and Decentralization alternatives. The one exception is the partial examination of naval SNF at the Puget Sound Naval Shipyard under Decentralization alternative 2B. Under all other alternatives, these five sites would transport naval SNF to one or several of the larger five DOE sites analyzed in this EIS, and evaluated from an environmental justice perspective in Section L-4.2.2.

L-4.2.1.1 Incident-Free Human Health Effects and Environmental Impacts. As

discussed in Appendix D to Volume 1 of this EIS, the impacts on human health or the environment resulting from operations associated with the management of naval SNF at any of the five locations limited to the storage of naval SNF would be small under any of the alternatives considered. This includes the impacts of incident-free transportation. For example, it is unlikely that a single fatal cancer would occur as a result of naval SNF management activities under any alternative at any one of the five sites. Also, it is unlikely that a single fatal cancer would occur as a result of activities associated with naval SNF examination under any alternative considered in the EIS. In fact, naval SNF could be managed at any of the five sites for between 7,100 and 43,500 years (depending on the site) before a single fatal cancer would be expected. Because the impacts as a result of incident-free operations present no significant risk and do not constitute a reasonably foreseeable adverse impact to the surrounding population, no disproportionately high and adverse effects would be expected for any particular segment of the population, minority populations and low-income populations included (see Tables L-2 and L-4).

L-4.2.1.2 Human Health Effects and Environmental Impacts Because of Accidents.

As discussed in Appendix D, the impacts on human health and the environment resulting from the risk of facility or transportation accidents at any of the five locations limited to the storage of naval SNF would be small under any of the alternatives considered. As explained in the EIS, the risk to the public is defined as the potential consequence of an accident multiplied by its probability of occurrence. This risk calculation represents the expected impact to members of the public. Based on this risk calculation, it is unlikely that a single fatal cancer would occur from reasonably foreseeable facility or transportation accidents related to naval SNF management activities under any of the alternatives. Because the potential impacts as a result of an accident for any of the alternatives considered would present no significant risk and do not constitute a reasonably foreseeable adverse impact to the surrounding population, no disproportionately high and adverse effects would be expected for any particular segment of the population, minority populations and low-income populations included (see Tables L-2 and L-4).

L-4.2.1.3 Effects of Natural Motive Forces. Impact analysis indicates that there would not be

disproportionately high and adverse impacts on human health and the environment resulting from the prevailing winds or the direction of surface or subsurface water flow. This is true for site operations because the effects of routine operations on air and water quality are so small. It is also true for accident conditions because the consequences of any accident, however unlikely its chance of occurrence, would depend on the random conditions at the time it occurred. The wind conditions at the Pearl Harbor Naval Shipyard are variable, but the predominant wind direction is toward the southwest, away from land and residential areas. The wind directions at the other four sites are highly variable with no strongly dominant direction.

L-4.2.1.4 Effects on Subsistence Consumption of Fish and Wildlife. Available data do

not show potential for disproportionately high and adverse impacts to minority and low-income communities related to subsistence consumption of fish and wildlife in the vicinity of these five sites under any alternative. Environmental monitoring in the vicinity of these relatively small and restricted sites has shown no detectable difference in the amounts of radionuclides present in the environment from levels in similar parts of their respective regions.

L-4.2.2 Results of Environmental Justice Assessment Near the Alternative Sites

Considered for the Management of All or Some Portion of DOE Spent Nuclear Fuel

The five sites evaluated for the management of all or some portion of DOE SNF are specifically addressed in Appendices A (Hanford Site), B (Idaho National Engineering Laboratory), C (Savannah River Site), and F (Nevada Test Site and the Oak Ridge Reservation) to Volume 1 of the EIS. It should be noted that these five alternative sites are considered for the management of DOE SNF under all alternatives analyzed in this EIS. The one exception is the Nevada Test Site, which is not considered in the No Action, Decentralization, and 1992/1993 Planning Basis alternatives because no SNF is currently managed at that site.

L-4.2.2.1 Facility Operations. This EIS considers the impacts from the operations of both

existing and new facilities on a site-by-site basis as appropriate for programmatic decisionmaking. Site-specific implementation of the programmatic strategy for the management of SNF for the 40-year interim period between 1995 and 2035 will be subject to additional National Environmental Policy Act review, as appropriate on a case-by-case basis. Both incident-free operations and reasonably foreseeable accidents were analyzed in terms of risk to both workers and the public. The potential impacts calculated for both incident-free operations and the risk of reasonably foreseeable accidents present no significant risk and do not constitute a reasonably foreseeable adverse impact to the surrounding population as discussed below. Therefore, no disproportionately high and adverse effects would be expected for any particular segment of the population, minority populations and low-income populations included.

L-4.2.2.1.1 Incident-Free Operations-In Table K-2 of Volume 1 of this EIS, it is

shown that under all the alternatives, the estimated number of latent cancer fatalities from the normal operation of DOE SNF management facilities would range from approximately zero to about two latent cancer fatalities over the 40 year period, or about 0.05 latent cancer fatalities per year. Therefore, no disproportionately high and adverse effects would be expected for any particular segment of the population, minority populations and low-income populations included (see Tables L-3 and L-5).

L-4.2.2.1.2 Reasonably Foreseeable Accidents-As explained in Section 5.1.1.4 of

this EIS, the risk to the public is defined as the potential consequence multiplied by the probability of occurrence. This risk calculation represents the expected impact to members of the public. The calculated risk of latent cancer fatalities associated with reasonably foreseeable facility accidents is small for all alternatives. The evaluated facility accident with the highest risk (breach of a fuel assembly for the Centralization alternative at the Savannah River Site) would result in an estimated 0.0072 latent cancer fatality per year, which equates to one fatal cancer in 140 years of operation. Impacts from high-consequence, low-probability accident scenarios would be adverse should they occur; however, the impacts to specific population locations would be subject to meteorological conditions on the day of the accident. Whether or not such impacts would have disproportionately high and adverse effects with respect to any particular segment of the population, minority and low-income populations included, would be subject to natural motive forces, including random meteorological factors (see Tables L-3 and L-5).

L-4.2.2.1.3 Natural Motive Forces-Offsite health effect impacts from operations and

reasonably foreseeable accidents are propagated by natural motive forces such as meteorological conditions and water pathways, both surface and subsurface. Impacts because of incident-free operations are dominated by prevailing patterns in these natural motive forces, whereas the impacts of an accident, should one occur, would be random based on the meteorological conditions at the time of and following occurrence. The following conditions are prevalent at each of the five large DOE sites under consideration:

Prevailing winds for the Idaho National Engineering Laboratory are primarily from the southwest, although winds at the Test Area North are frequently from the north and west-northeast. Local rivers and streams drain mountain watersheds to the north and west of the Idaho National Engineering Laboratory, but most surface water is diverted for irrigation before it reaches the site boundaries. Groundwater in the underlying Snake River Plain Aquifer generally flows to the south and southwest (see Figures L-8 and L-18).

Prevailing wind conditions at the Savannah River Site are from the northeast and west-southwest. Both onsite surface streams and groundwater aquifers generally drain in a southwesterly direction, toward the Savannah River, which flows southeast to Savannah, Georgia (see Figures L-6 and L-16).

The prevailing wind direction at the Oak Ridge Reservation is from the southwest, with a secondary pattern from the northeast during the winter, spring, and summer months. The situation is reversed in the fall. Surface and shallow subsurface water in an area susceptible to the potential siting of SNF management facilities would flow south into Grassy Creek and then to the Clinch River. The Clinch River flows southwest and west around the reservation and subsequently to the Tennessee River. Deeper groundwater tends to remain relatively stationary because of high retention times (see Figures L-7 and L-17).

Prevailing winds at the Nevada Test Site are from the south during the summer and the north during the winter. Surface topography usually results in a wind reversal from the south in the day to the north during the night. Almost all surface water is transient and short-lived in nature. In an area susceptible to the siting of SNF management facilities, surface water would flow east towards Frenchman Lake, where it would be lost by evaporation or recharge to the local groundwater system which discharges to the southwest. Water discharged beneath the site would likely either evaporate or remain indefinitely because of the great depth of the groundwater at the site (see Figures L-10 and L-20).

Prevailing winds at the area of interest on the Hanford Site are from the northeast in all months of the year, with the second predominant pattern occurring from the southwest, primarily during the spring and fall. Roughly two-thirds of any surface water runoff would drain to the Columbia River, with the rest draining to the Yakima River and joining the Colombia River below the Hanford Site. Groundwater systems underlying the Hanford Site tend to flow toward the Columbia River in a southeast and northeast direction (see Figures L-9 and L-19).

As indicated in Appendix K of this EIS, the risk of impacts from incident-free routine operations and from reasonably foreseeable accidents is so small that the propagation by motive forces is essentially of no consequence.

L-4.2.2.2 Transportation. Transportation corridors associated with shipment of SNF

management by either truck or rail can be classified as roughly 80 percent rural, 17 percent suburban, and 3 percent urban. Specific details of mileage and percentages by route are contained in Table I-1 of Appendix I to Volume 1 of the EIS.

L-4.2.2.2.1 Incident-Free Transportation-For incident-free transportation, the total

number of potential fatalities would be the sum of the health effects because of exposure to radiation and vehicular emissions. The total number of shipments over the 40-year period would vary from about 200 during the transition period for naval SNF under the No Action alternative to about 7,400 shipments if all of DOE's SNF were managed at the Nevada Test Site under the Centralization alternative. The DOE's preferred alternative would result in a total of approximately 3,700 shipments among the sites. The estimated total latent cancer fatalities resulting from incident-free transportation is less than two under the maximum shipment (Centralization) alternative, while the preferred alternative results in less than one fatality.

L-4.2.2.2.2 Transportation Accidents-It is worth noting that the risk of fatalities

associated with vehicular accidents during the transport of SNF is higher than the risk of cancer caused by radiation exposure because of such accidents, although both are very small. Also, the risks associated with radiation because of transportation accidents is even less than the small risk associated with facility accidents. The reasonably foreseeable transportation accident scenario with the largest consequences (SNF rail shipment accident occurring in an suburban area) would lead to 55 latent cancer fatalities; however, the probability of this scenario occurring is about 1 in 10 million. The overall risk (probability multiplied by consequence) of all accidents analyzed, including the above scenario, over the total 40-year timeframe analyzed is much less than one fatality. Over this 40-year timeframe, up to two fatalities could result from vehicular traffic accidents themselves without any radiological releases. When and where an accident occurred, if one in fact occurred, would be completely random with respect to the immediate and surrounding population, as well as the motive forces that could propagate the impacts during the timeframe of occurrence. Although adverse impacts could occur in the unlikely event of a high-consequence accident, any potential disproportionality with respect to any population, minority and low-income populations included, is subject to the randomness of the combination of factors that can produce such impacts.

L-4.2.2.3 Subsistence Consumption of Fish, Wildlife, or Native Plants. The

calculations in this EIS estimate dose and risk from ingestion of radioactive materials based on site-specific agricultural data and assume a typical dietary pattern. Subsistence consumption of fish, wildlife, and native plant species is not explicitly addressed in these analyses. However, the calculations in this EIS include several conservative assumptions that bound the potential for ingestion of radioactivity through these special exposure pathways. In particular, these calculations assume that a very high proportion of the diet is based on locally grown produce and locally grazed livestock, both of which are produced at locations representing the highest calculated concentrations of radioactivity. Nevertheless, there may be some differences between the uptakes of grazed livestock and free-ranging game. No human populations in the immediate vicinity of the any of the five DOE sites are known to subsist entirely on locally harvested fish or wildlife. Fishing is not usually allowed on DOE sites, but some hunting is allowed under controlled conditions.

Game species, locally grazed livestock, fish, locally grown foodstuffs, and native plants around DOE sites are routinely sampled for radionuclides. Concentrations of radionuclides in samples have generally been small, and are seldom elevated above those observed at locations distant from these sites where the principal source of non-natural radionuclides is very small amounts of residual global fallout from past nuclear weapons tests. Data from monitoring programs are reported annually in site-specific environmental reports.

If SNF management activities were to increase wildlife losses because of vehicle collisions with game, there might be a disproportionate impact to minority or low-income communities that rely primarily on hunted game. However, the maximum potential increases in shipments of SNF would be small additions to current rail and highway traffic, so the overall impact to wildlife would be small. Potential mitigation measures for any resulting adverse impact to low-income or minority populations include distributing the deceased animals to hunters in the vicinity known to partially subsist on game, controlling subsequent hunts, or relocating game if necessary.

L-4.2.2.4 Other Considerations. In addition to the above, reviews of other technical disciplines

pursuant to the methodology in Section 4.1 did not indicate any significant adverse impacts because of land use, socioeconomics, water and air resources, ecology, cultural resources, or cumulative impacts. Therefore, no disproportionately high and adverse impacts were identified for any segment of the population. Of particular interest are the following:

L-4.2.2.4.1 Socioeconomics-Depending upon the various alternative evaluated, the

total labor force involved in SNF management could decrease by up to 180 jobs or increase by more than 2,100 jobs averaged over the 10-year implementation period between 1995 and 2005. Affirmative action programs would distribute such effects proportionately among workers, whereas coordination of planning activities with local communities would be intended to avoid placing undue burdens on local community resources. DOE may also provide support to local agencies if necessary to mitigate localized impacts.

L-4.2.2.4.2 Land Use, Ecology, and Cultural Resources-None of the alternatives

would have a significant adverse impact on land use, ecology, and cultural resources because of the limited amount of previously undisturbed land which would be needed for use onsite (no offsite lands are involved) and mitigative programs already in place. These programs include working closely under agreements with State Historical Preservation Officers and Tribal governments regarding preservation of historic and cultural resources. Consultations with Tribal governments have expanded the DOE's awareness of Tribal interests and values with respect to nature, religion, and the land, and are designed to avoid or relocate these resources as possible. If avoidance were not possible, data recovery (such as archiving artifacts) or other mitigation measures may be developed in consultation with affected Tribes and the respective State Historical Preservation Officer, as appropriate. Similarly, the DOE is aware of sensitive ecological resources, and avoids wetlands and endangered plant or animal specie habitats. Disturbance of certain ecological resources (which are not federally listed as threatened or endangered) is possible, but not likely. The reasonably foreseen environmental impacts, if any, to land use, ecological resources, or cultural resources are expected to be small under any of the alternatives.

L-4.2.2.4.3 Cumulative Impacts-Based on the analysis of the impacts for each of the

disciplines analyzed in this EIS, along with the impact of other past, present, and reasonably foreseeable future activities at each of the alternative sites, no reasonably foreseeable cumulative adverse impacts are expected to the surrounding populations, minority populations and low-income populations included (see Tables L-2 through L-5).

L-4.2.2.5 Impacts Because of Perception. Potential adverse impacts may result from the

public's perception of risk associated with nuclear industry activities in general and DOE's activities in particular. For example, a SNF management facility has the potential to increase awareness of the nuclear industry, leading to concerns of potential adverse effects to the conduct of local commerce, whether it be tourism, agriculture, or the like. From both a National Environmental Policy Act and an environmental justice perspective, both the character and substance of these potential impacts is not discernable. Therefore, it is not possible to identify any quantifiably adverse or disproportionately high distribution of any impacts of such perceived risk.

In order to better understand and help mitigate unfounded perceptions, the DOE is working to enhance the general population's understanding of the potential impacts of DOE programs in general and the proposed action in particular, with emphasis on minority populations, low-income groups, and Tribal governments.

L-4.2.3 Perspective

To place the impacts in perspective with respect to risks encountered in everyday life, in 1990, there were approximately 510,000 cancer deaths in the United States population, of which about 64,000 were among the nonwhite population. This equates to an average of roughly 1,132 cancer fatalities (of which 142 would affect minority populations) in an area comparable to that included in the 80 kilometer (50 mile) radius around any of the sites considered in this EIS. Additionally, in 1992, there were about 40,000 traffic fatalities in the United States, of which about 7,400 were among the non-white population. This equates to an average of roughly 89 traffic fatalities (of which 16 would affect minority populations) in an area comparable to that included in the 80-kilometer (50-mile) radius around any of these sites. Based on the risk of additional fatalities provided in Sections L-4.2.1, L-4.2.2.1.2, and L-4.2.2.2.2, the risk to the surrounding population because of DOE SNF management activities would not appreciably increase this total, even if all impacts were associated with minority or low-income populations.

L-5 CONCLUSIONS

The overall review indicated that the potential impacts calculated for each discipline under each of the alternative sites considered for the management of all or some portion of DOE SNF (or naval SNF only) present no significant risk and do not constitute a reasonably foreseeable adverse impact to the surrounding population. Therefore, the impacts of the programmatic management of DOE SNF under all alternatives evaluated in this EIS do not constitute a disproportionately high and adverse impact on any particular segment of the population, minorities or low-income communities included, and thus do not present an environmental justice concern.

The approach to evaluating environmental justice used in this EIS may differ from future guidance issued by the Interagency Working Group or the DOE. Nevertheless, as demonstrated by the different approaches discussed in Section L-3.5, the conclusions are not expected to change because the impacts resulting from the proposed action under all alternatives present no significant risk to the potentially affected populations. As a result, no disproportionately high and adverse effects would be expected for any particular segment of the populations, including minority populations and low-income populations.

L-6 REFERENCES

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